1952, No. 4 December 26

Copeia

ESTABLISHED IN 1913

PUBLISHED BY

THE AMERICAN SOCIETY OF

ICHTHYOLOGISTS AND HERPETOLOGISTS

Copeia *1952, No. 4* *December 26*

CONTENTS

Published quarterly at Mt. Royal & Guilford Aves., Baltimore 2, Md. by the American Society of Ichthyologists and Herpetologists, the Museum of Zoology, University of Michigan, Ann Arbor, Michigan. Entered as second class matter at the Post Office at Baltimore, Md. under the Act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized February 11, 1924.

1952, No. 4 COPEIA *December 26*

The Status of the Turtles *Graptemys pulchra* Baur and *Graptemys barbouri* Carr and Marchand, with Notes on Their Natural History

Fred R. Cagle

THE TURTLES of the genus *Graptemys* have long been a source of confusion to herpetologists. Misleading taxonomic and ecological conclusions based on fragmentary information are a result of the extreme variation in morphology together with the inadequacy of the material available for study.

The difficulty of collecting these turtles in quantity has prevented the accumulation of series in museums. Members of each species are shy and tend to inhabit deeper or faster flowing waters than do other Emydid turtles. Attempts to collect them on the Gulf Coast by net, trot line, and seine from 1944 to 1948 were unsuccessful. Not until a technique of hand collecting (Chaney and Smith, 1950) was developed could useful series be taken. A concentrated attempt was made during the summers of 1949 and 1950 to collect samples from the major streams of Louisiana. Planned sampling is now in progress to develop a collection adequate for the solution of some of the many taxonomic and ecological problems.

A preliminary study of more than 500 specimens from Texas, Louisiana, Mississippi, Alabama and Florida in the Tulane Collection and selected series in museum collections (United States National Museum, American Museum of Natural History, Chicago Natural History Museum, Museum of Comparative Zoology, University of Illinois Museum of Natural History, Milwaukee Public Museum, Natural History Museum of University of Minnesota) clearly indicates that the genus is more complex than has been generally recognized, that a number of new forms must be defined, and that proper clarification of the problems cannot be achieved with the materials now available in museum collections.

It is the intent of the author to follow the procedure established by Roger Conant in his analysis of the genus *Natrix*. Each species or complex will be treated as materials are available for solution of the selected problems.

These investigations are made possible by the enthusiastic field activities of a group of Tulane students. I am particularly grateful to A. H. Chaney, Clarence Smith, Paul Anderson, Ernest Liner, John Boley, Samuel Nichols and Richard Etheridge.

Collections made by Tulane University summer expeditions in 1949 and 1950 provided 422 specimens of *Graptemys pulchra* and *G. barbouri* which were preserved and data were recorded in the field on 200 additional specimens that could not be retained. This material is used here as a basis for the description of three populations of the two species.

The following abbreviations are used: Cl. = carapace length; Cw. = carapace width; Pl. = plastron length; Hw. = head width; Av. = alveolar width (upper jaw). All measurements are maximum.

Graptemys pulchra Baur

Baur (1893) described *pulchra* from two turtles (USNM 8808) collected from a lake near Montgomery, Alabama by J. Bean and L. Kumlein in 1876. The description differentiates *Grapetemys pulchra* on the basis of (1) "The whole space between and behind the orbits is characterized by a continuous yellow figure, which sends backwards on each side behind each orbit a strong process of the same color."; (2) "In all the skulls examined the jugal is excluded from the orbit, a character not seen in the other species of *Graptemys* or *Malaclemmys*." Baur stated that the head resembles that of *G. kohni* but is more slender and the symphysis of the lower jaw longer. He added that the carapace is "very close" to that of *G. kohni*, the dermal shields are thin, the shell is light olive with yellow marks on the marginals, and some dark marks on the plastron.

The following description is the result of a reexamination of one of the cotypes, USNM 8808, female. Maximum carapace length 17.6 cm., carapace width 13.9, plastron length 16.4,

plastron width 8.4, height 7.2, head width 3.2. Carapace shields crossed with network of yellow (?) lines bordered with black. Ridge of carapace low, short; inconspicuous middorsal projection on the rear of the second vertebral. Plastron immaculate. Head conspicuously marked with a light zone covering the interorbital area and a zone posterior to the eyes equal in width or almost as wide as the diameter of the orbits; two bars, the upper the longer, project posteriorly from this light zone. Upper jaw darkened; the lower with a broad light zone covering its rear half. Ventral surface of lower jaw with two longitudinal bars anteriorly, an irregular pattern of light lines forming interrupted half-loops posteriorly.

The specimen may have been taken from waters associated with either the upper reaches of the Alabama River which enters the Tensas River or one of the tributaries of the Escambia River which enters the Gulf of Mexico at Pensacola. In all likelihood the turtle may be associated with the Alabama drainage. Regardless of exact locality, the specimen was taken from near the eastern limits of the range of *Graptemys pulchra* and the western limits of the range of *G. barbouri* (Fig. 1).

The second specimen (catalogued with No. 8808; now USNM 029526) is a juvenile female. Maximum carapace length 17.8 cm., carapace width 12.7, plastron length 16.4, plastron width 8.2. It differs from No. 8808 in having the spines of the vertebrals less elevated and the markings of the costals and marginals scarcely evident. The skull, removed by the former division of Comparative Anatomy and stored in the reptile division as No. 029526, has the jugal excluded from the orbit as Baur mentioned and the alveolar surfaces but slightly broadened (skull width/alveolar width = 3.26). The greatly elaborated ridges and occipital shelves typical of larger females are not developed.

A second skull catalogued as No. 29526 and originally labeled "cotype" is probably the skull of a female of *G. oculifera*. The jugal broadly enters the orbit, the frontals project between the nasals to form a point, the alveolar surfaces are narrow, the parietals do not form a shelf projecting over the temporal opening

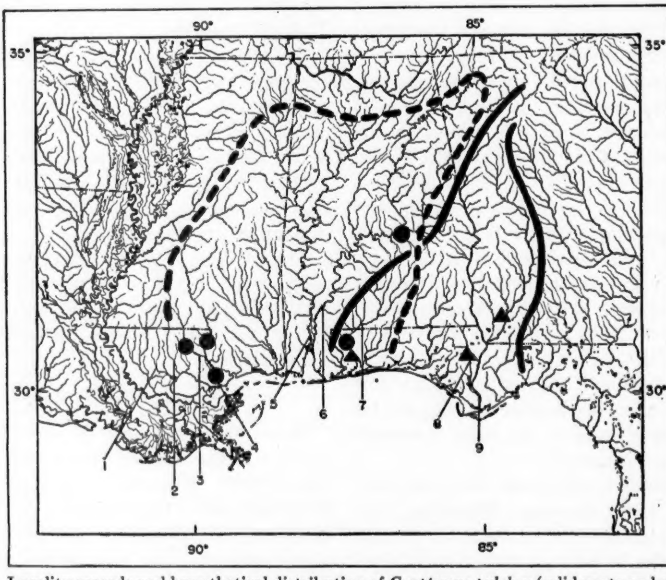


Fig. 1. Locality records and hypothetical distribution of *Graptemys pulchra* (solid spots and area enclosed by broken line) and *G. barbouri* (triangles and area enclosed by solid line). Numerals refer to the following rivers: 1, Amite; 2, Tangipahoa; 3, Bogue Chitto; 4, Pearl; 5, Tombigbee; 6, Alabama; 7, Escambia; 8, Chipola; 9, Apalachicola.

and the skull has the generally light architecture of *G. oculifera*. The identification of this skull was questioned on the original tag by Stejneger.

DESCRIPTION OF JUVENILES.—This description is a composite drawn from ten juveniles from the Pearl River (Tulane 14001, 12361,

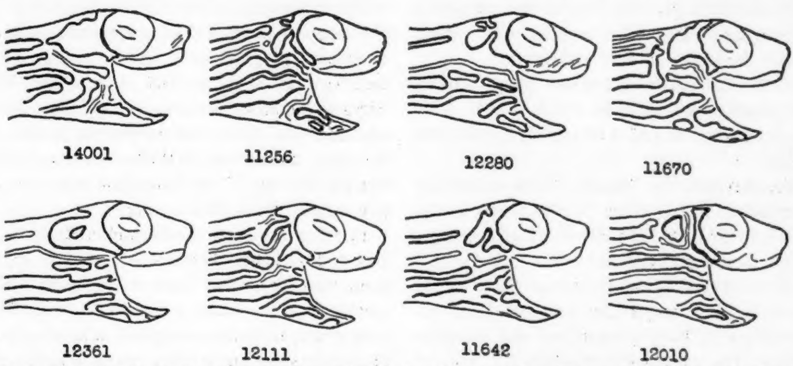


Fig. 2. Variation in head markings of juveniles of *Graptemys pulchra* (Tulane University collections).

12280, 11256, 12111, 11670, 12010, 11669, 12192) that range in plastron length from 3.5 to 4.9 cm. and are either hatchlings or turtles in their first growing season.

The head markings are exceedingly variable but in every turtle include a yellow interorbital zone and a large postorbital blotch with a distinct black border (Fig. 2). The postorbital blotch assumes varied shapes. It may cover an area approximating that of the orbit (Tulane 14001) or it may form a branched figure (Tulane 12111). In an occasional individual it is divided into a postorbital vertical bar and an oval blotch (Tulane 12010). The lateral head stripes may be continuous or broken to form oval spots. Usually there is a basic pattern of four or five black-edged yellow stripes interspersed with feebly defined striping (Fig. 2).

The pattern of the ventral surface of the jaw is much less variable (Fig. 3, C). The yellow color of the horny jaw covering is extended posteriorly at the symphysis to form an inverted T bordered laterally by longitudinal yellow lines. Posterior to these are two broad yellow lines which are usually joined centrally.

The carapace is generally olive-green with faint indications of semi-circular or curved yellow markings on the costals. A well-defined middorsal stripe extends from the 1st to the 5th vertebral. Each marginal has a wide semicircular yellow black-bordered mark (Fig. 4). The 2nd, 3rd, 4th vertebrals have conspicuous spines. The height of the 2nd is equal to the length of the suture between the 1st and 2nd marginal. The spines are remarkably uniform in shape and height as contrasted with those of *Graptemys oculifera* in which they are exceedingly variable. The plastron is yellow except for a narrow black border on the posterior edge of each scute.

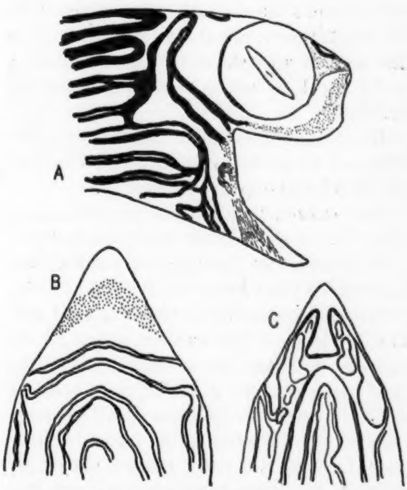


Fig. 3. Color pattern in juveniles of *Graptemys*. A and B, head and lower jaw of *barbouri*; C, lower jaw of *pulchra*.

The anterior surface of the forelimb has a yellow stripe extending onto each digit; that

to the 2nd is the wider. Each stripe is black bordered. Similar striping is present on the rear limb. The stripes are variable in that they may unite to form Y shaped marks or may remain independent. There is no evident trend in this series.

The projecting rear corners of the 5th to 12th marginals give the edge of the carapace a serrate appearance. The carapace width about equals the length in the hatchlings.

In 13 individuals of the size group 4–5 cm. the plastron length/head width is 3.40–4.00; the head width is 3.85–4.60 that of the alveolar width.

DESCRIPTION OF MALES.—This composite description is based on four males (Tulane 13447, 13798, 12055, 13459) ranging in plastron length from 7.6 to 8.4 cm.

All markings are as distinct as those of the juveniles. The major changes that have occurred are in body proportions and carapace outline. The carapace is elongate (Cl./Cw. = 1.23–1.27) and only the posterior marginals (8–12) form a serrate border. The spines of the 1st and 4th vertebrals are lost and those of the 2nd and 3rd are reduced (height of 2nd = $\frac{1}{2}$ to $\frac{2}{3}$ length of suture between 1st and 2nd marginal).

The head is broadened (Pl./Hw. = 4.61–4.91) and the alveolar surfaces expanded (Hw./Aw. = 3.85–4.06) proportionately.

The plastron length of the largest male is 11.72 cm.; of the smallest mature male, 8.9.

DESCRIPTION OF FEMALES.—Three individuals from the Pearl River (Tulane 12056, 12486, 11900) have respective plastron lengths of 13.3, 17.0 and 19.5 cm. The smallest individual is a juvenile; the others are sexually mature. The color patterns of the 2 smaller individuals are similar to that of the juveniles described except that the black borders of the plastral sutures are reduced in No. 12056 and are but faintly visible on the pectoral and humeral scutes. The largest individual, No. 11900, has the original pattern of the head markings almost obliterated by the development of black pigment. The interrupted outlines of the pattern is still apparent (Fig. 5). The markings of the lower jaw are not obscured.

The carapace is not much wider posteriorly (maximum width into maximum length: 1.30, 1.38, 1.42) and the spines typical of the juveniles are reduced to ridges on the 2nd and 3rd vertebrals.

The head is conspicuously broadened in the largest female (No. 11900) and, in relation to width of the carapace, is the widest head observed for any individual of the genus. The plastron length is 3.54 to 4.16 times the head width in the smaller individuals, but is 3.18 in the largest female. The alveolar surfaces have a greater proportionate width in the large females (Hw./Aw. = 3.09, 3.76, 2.93). The edges of the upper jaw are much thickened and rounded. The downward projecting section of the upper jaw is 9 mm. in thickness in the largest female. The tip of the lower jaw is somewhat pointed and fits within the upper.

Five females from the Escambia River (Tulane 13457, 13446, 13460, 13459, 13472) differ from those from the Pearl River in that the markings of the lower jaw tend to be broken into erratic lines that constitute a longitudinal pattern in some and a transverse one in others.

The skull of a female (Tulane 13472, Escambia River) is typical of large individuals. Its most conspicuous difference from those of other species of *Graptemys* is the exclusion or near exclusion of a jugal from the orbit (Fig. 6), a feature noted by Baur in his description. In this specimen the jugal is separated from the orbit on the left side by a downward extension of the postorbital; on the right side the jugal sends a branch forward which almost reaches the edge of the orbit. In general configuration and the development of ridges, processes and spines the skull approximates closely that of *Graptemys barbouri*. It is different in the greater thickness of the edge of the upper jaw, the greater space between the maxillaries, and the reduction of the prootics. It differs from the skulls of the *Graptemys pseudogeographica* group, the *G. versa* group and *G. oculifera* in many respects. These will be discussed in a forthcoming report.

RANGE.—Map turtles have been collected in the Pearl River from the town of Pearl River, Louisiana, northward to a section of the river west of Varnado, Louisiana. They have also been collected from a tributary of the Pearl, the Bogue Chitto, near Enon, Louisiana, and the Escambia River in western Florida (Fig. 1). They are much more abundant in the Pearl River than in the Bogue Chitto, if counts of

individuals on basking sites and collecting results are acceptable indications of relative abundance. None were found in the Amite and Tangipahoa Rivers or observed at basking sites. Their absence in these rivers is puzzling since the habitat is apparently suitable. Although more than 1200 specimens of *Graptemys* have been taken from 21 localities in Louisiana and Mississippi in the last 4 years, *G. pulchra* has not been collected west of the Bogue Chitto. Too, examination of many thousands of hatchling turtles from central Louisiana, purchased for the pet trade, has never revealed a specimen of *G. pulchra* and the dealers do not know the turtle. It thus appears that the Pearl River drainage forms the western limit of the range for this species as it does for *Graptemys oculifera*.

As striking and puzzling as the abrupt delimitation of the distribution of *Graptemys pulchra* and its absence from an apparently suitable habitat in a closely adjacent drainage is the total absence of any representative of the *G. pseudogeographica* group from the Pearl River drainage or the Gulf Coast rivers to the east. The records of Baur (1892) from Pensacola, Florida, are based on specimens shipped by Gustave Kohn from New Orleans and purchased in the local French Market (Beyer, 1900) and cannot be accepted without further verification. The explanation of these distribution patterns rests on a knowledge of the ecology not yet available and, although speculation may be entertaining, it would contribute nothing here. Carr (1952: 212) states in regard to *G. pulchra* "It is possible that this turtle intergrades with *G. p. kohnii* in Mississippi and Louisiana. It seems more likely, however, that intergradation with *oculifera* will be found, provided the latter proves to be valid." There is no evidence in support of either conjecture.

Habitat.—The Pearl River has a shallow channel with a sand and gravel bottom. The fast current causes fluctuations in depth, with sand bars building and disappearing rapidly. The meanders have steep outer and gently sloping inner banks of fine sand and gravel. The inner banks provide an excellent habitat for a variety of clams and snails and near ideal egg-laying sites for some turtles.

The mapturtles live in the slower currents in the deeper waters and venture into the shallow water or onto sand beaches only at night or during the egg-laying season. They choose logs or debris over deep water for basking and from such sites plunge into the water at the slightest disturbance. Basking individuals can be observed satisfactorily only with the aid of binoculars or a telescope.

The turtles usually remain in the same area of water at night. Collectors found that the best method of selecting a spot for night work was to survey the river for basking sites. A return to such places at night yielded excellent results while other areas were explored unsuccessfully.

The turtles are easily observed at night as they cling to submerged objects a few inches below the water surface. They appear to be resting quietly (sleeping?) and may be picked up, if extreme caution is used in approaching them or if they are approached very rapidly. The most successful collecting team, Mr. A. H. Chaney and Mr. Clarence L. Smith, owe their success to skill in coordinating movements. One operated an outboard motor, directing the rapidly moving boat over a resting turtle so that it could be reached by the other. The preferred resting sites of the mapturtle are frequently the half submerged branches of locust trees. Success is often the consequence of permitting enthusiasm to override the pains of thorns penetrating the flesh.

Growth.—All growth determinations were made from the analysis of growth rings using the procedure described by Cagle (1946).

The plastron lengths of the hatchlings is 2.15–3.53, mean 3.02 cm., as calculated from the measurements of the birth rings of 29 individuals one to two years old. The calculated sizes for subsequent years follow: 1st year 3.53–5.14, mean 4.37 cm. (29 individuals); 2nd, 4.56–5.93, mean 5.11 (21); 3rd, 5.60–6.57, mean 6.09 (6); 4th, 6.32–6.90, mean 6.74 (3, 2 of them mature males).

Of the nine sexually mature males examined, the smallest had a plastron length of 7.12 cm. The latter, in its fourth season of growth, was the only one of the nine that retained growth rings distinct enough to be measured. This animal was 2.67 cm. at hatching, 4.45 at the end of the first season, 6.05 at the end of the second and 6.60 at the end of the third. The smaller males had grown slightly during the last growing season; the larger ones had no

evidence of recent growth. All males larger than 7.12 cm. were sexually mature.

The smallest sexually mature female had a plastron length of 17 cm. and it was assumed that all females above that size are sexually mature. Of the six juvenile females in the size range 10–15 cm., only one (Pl. 10.3 cm.) had grown during the 1950 season. A juvenile female (Pl. 6.80 cm.) from the Pearl River was 2.27 cm. in length at hatching, 4.24 at the end of the first growing season and 5.93 at the end of the second. A larger juvenile female from the Escambia River (Pl. 14.7 cm.) had grown rapidly, having increments of 6 mm. and 13 mm. for the last two seasons.

Breeding Habits.—Two of the larger individuals contained eggs. One collected from the Pearl River, June 8, 1951, plastron length 17.0 cm., had 2 eggs in the left oviduct and one in the right. These measured respectively: length 4.27, 4.73, 4.60 cm.; width 2.58, 2.70, 2.50 cm. The right ovary had three ovulation points (corpus luteum, corpus albicans), the left, none. There were three enlarged ovocytes (0.8, 0.9, 2.05 cm. in diameter) in the left ovary and three (1.4, 2.1, 2.2 cm. in diameter) in the right. This was thus the first clutch of eggs of the season.

A female, plastron length 20.7 cm., collected July 15, 1951, from the Escambia River contained six eggs, two in the left oviduct and four in the right. Five of the eggs measured respectively: lengths 3.80, 3.87, 3.96, 3.98, 4.0 cm.; widths 2.42, 2.42, 2.43, 2.50, 2.47 cm. The right ovary had eight ovulation points and no enlarged ovocytes, the left six ovulation points and no enlarged ovocytes. This female had produced a total of 14 eggs that season, eight in the first clutch (or clutches) and six in the last.

Food.—A separate study is in progress on the food habits of the mapturtles. A cursory analysis of the stomach contents of two males from the Pearl River indicated that only the remains of insects were present. The intestinal contents of a juvenile female from the Pearl River and two adult females from the Escambia River included only fragments of clams and snails. Some of the shell fragments were 38 mm. in length and 1.6 mm. in thickness.

Graptemys barbouri Carr and Marchand

Graptemys barbouri was described (Carr and Marchand, 1942) from specimens taken in the Chipola River, north of Marianna, Florida. Carr and Marchand did not report characters differentiating *Graptemys barbouri* from *Graptemys pulchra* but stated "With respect to head markings *barbouri* is most closely approached by the type specimens of the neglected but possibly valid *pulchra*, described by Baur from Montgomery, Alabama. However, photographs and sketches of the type (United States National Museum 8808), kindly furnished by Doctor Stejneger, appear to demonstrate that in other respects *pulchra* agrees most closely with *pseudogeographica* and is very different from *barbouri*." Carr and Marchand believed that *G. barbouri* is most closely allied to *kohni*. They (*op. cit.*: 98) distinguished *barbouri* from all other species of *Graptemys* by the "excessively enlarged heads and expanded alveolar pavement of the jaws and by the nature of the markings of carapace and plastron."

A series of 393 individuals from the Chipola River was available for the present study.

Description of Juveniles.—This description is based on ten individuals (Tulane 13338–6, 13363–9, 13363–3, 13363–8, 13363–12, 13363–5, 13363–6, 13363–16, 13363–14, 13338–3) in their first season of growth (plastron length 3.6–4.9 cm.). The head markings consist of a light yellowish green interorbital zone which is interrupted by a Y-shaped black mark just posterior to the orbits. A branch from the interorbital zone extends downward to a point under the eye. The width of the postorbital marking may be as little as one fourth of or equal to the diameter of the orbit. Below this mark a wide yellow line extends along the neck to enter the area at the juncture of the jaws. This line may be broken posteriorly or joined by vertical lines extending upward. A second wide, longitudinal line may or may not join the former at its point of extension onto the lower jaw (Fig. 3A).

The lower jaw is distinctively marked by a pattern of transverse lines (Fig. 3B). A poorly delimited black zone borders the light horn colored edge of the jaw. Immediately behind this is a wide yellowish transverse band. Two black lines enclosing a narrower light zone are posterior to this. The ventral surface of the neck is dominated by two wide light lines that join just posterior to the symphysis of the

jaw. The rami of this figure enclose a midventral, light line. The background color of the head and neck is black.

The carapace is olive-green to dark horn. Each of the costals and marginals have a narrow semicircular, black bordered stripe. These markings are inconspicuous in most individuals. The 2nd and 3rd vertebrals have prominent, black-tipped spines. Their height may be equal to three fourths the length of the suture between the 1st and 2nd marginal. The 1st and 4th vertebral may have a low spine or merely a ridge. The spines, not well developed on these scutes in any individual, are black tipped (Fig. 4). In the smaller individuals the entire edge of the carapace is serrate as a result of the projection of the posterior margin of each marginal. The projections of the 1st to the 6th marginal are lost in the larger individuals of the series, leaving only the posterior border of the carapace serrate.

The plastron is yellow and without markings except for a narrow border of black on the rear edge of each scute. The most striking feature of the plastron is the development of a ridge on the abdominal and pectoral plates where they enter the bridge. The ridge, which may be elevated 2 mm. above the middle of the plastron, gives it a configuration unlike that of *Graptemys pulchra* (Fig. 4). In many individuals the pectoral and abdominal plates may bear a distinct spine-like projection which accentuates the ridging. This projection is 1.5 mm. in length in specimen No. 13338–6. Associated with the lateral ridge is the large distance between the plane of the edge of the carapace and the plane of the plastron (Fig. 4). This distance, measured vertically from the juncture of the 6th and 7th marginal with the edge of the plastron to a line drawn through the plane of the plastron, is about equal to the length of the suture between the pectoral and abdominal plates.

The anterior surface of the front legs has two wide yellow bands originating on the 2nd and 4th toes; the lower band is 2 to 3 times the width of the upper. A third band between these two is sometimes well developed.

The axillary and inguinal plates are visible from the lateral view.

Description of Males.—This description is based on ten males (Tulane 13312, 13486, 13410–66, 13410–68, 13410–65, 13410–58, 13410–12, 13410–57, 13410–64, 13410–3) ranging in plastron length from 6.9 to 9.6 cm. The smallest individual (No. 13312) was in its first season of sexual maturity. The largest male collected has a carapace length of 10.5 cm.

The color pattern differs from that described for juveniles in the loss of the yellow rings on the costals and marginals and the black borders on the plastral plates in the larger males. Melanistic, diagonal, streak-like areas are present on the costal plates of several turtles;

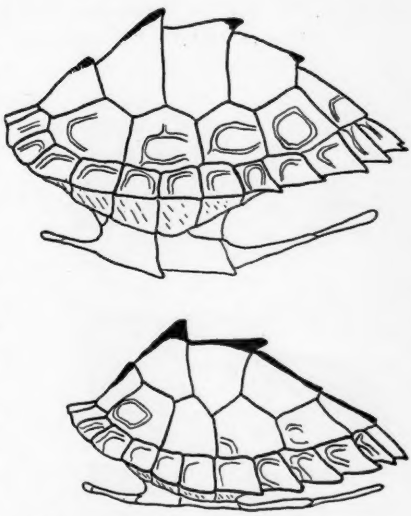


Fig. 4. Shell of *Graptemys barbouri* (upper) and *G. pulchra* (lower).

an occasional large male may retain the juvenile color pattern.

The carapace is elongate (Cl./Cw. = 1.18–1.36) and only the posterior marginals (9–12) form a serrate border. The spines of the 1st and 3rd vertebrals are lost and those of the 2nd and 3rd are reduced (height of 2nd = 1/3 to 1/2 length of suture between 1st and 2nd marginals). In the larger males the spine of the 3rd is represented only by a low ridge.

The plastron length is 4.73 to 5.80 times the head width (male in its 1st season of maturity is 4.73), and the head width is 3.15 to 3.80 times the alveolar width.

Description of Females.—This description is derived from a study of 112 individuals (48

young, 64 adults), but is specifically based on ten specimens (Tulane 13879–4, –5, –7, –9, –12, –16, –23, –26, –50, –77). The largest specimen has a plastron length of 27.1 cm. (Cl. 32.0). All are from the Chipola River.

The females retain the juvenile color pattern until they reach a plastron length of about 20 cm. Larger females tend to lose the carapace markings and the head pattern is gradually obliterated by the intrusion of black pigment (Fig. 5). The largest females retain but faint indications of the head pattern but do tend to retain the distinctive transverse bar on the lower jaw. This mark may be interrupted with black in very large females but it remains evident.

Fig. 5. Head of large female of *Graptemys barbouri* (upper) and *G. pulchra* (lower).

The carapace is flared posteriorly (maximum carapace width into the carapace length in 10 mature females is 1.18–1.46) and the spines of the vertebrals are reduced. There is no correlation of their reduction with the size of the turtle. Juvenile females may have the spines more reduced than the largest individual. One female (Pl. 22.6 cm.) has the spines of both the 2nd and 3rd vertebrals still evident (height = ¼ that of suture between the 1st and 2nd marginal).

The head is proportionately much broader than in the males. In 16 adult females (Pl. 18.0–25.5 cm.) the plastron length is 3.43–4.68 times the head width; the carapace width is 2.71–3.03 times the head width. The alveolar surfaces have a greater proportional width than in any other turtle (Hw./Aw. = 2.42–2.81). The cutting edge of the lower jaw is abraded so that it does not project beyond the alveolar pavement. The downward projecting edge of the upper jaw is thickened but, in most individuals, retains a cutting edge.

Many of the females have the lower jaw projecting 2 to 5 mm. beyond the upper (Fig. 5). This development is not clearly correlated with the size of the head. It is not characteristic of all the large females and it is evident in several smaller ones (Pl. 21.1, 22.4, 21.1 cm.).

A single female (Tulane 13471; Pl. 22.4 cm.) from the Escambia River is not different from the Chipola River females. A juvenile female from Baker County, Georgia, collected November 1, 1901 (University of Minnesota Museum of Natural History, No. 512; Pl. 13.7 cm.) is different from Chipola River specimens of the same size in that it has lost the juvenile head and carapace markings.

The skull of a large female (Pl. 23 cm.) is typical of a series of 12 examined. The skull is short and broad (Fig. 6); its maximum width is equal to the distance from the condyle to the tip of the premaxilla. The orbit is small; its maximum diameter is equal to that of the tympanum. The most conspicuous features are the much broadened maxillae and the development of ridges and projecting shelves on the occipital spine, the squamosal, the parietals and the postfrontals. The maxillae are broadened to the extent that they are separated in the midline only by a narrow portion of the vomer. Their height below the orbits is equal to the minimum width of the zygomatic arch. The frontals do not extend between the nasals (as they do in *Graptemys oculifera*) and the postfrontals and parietals have their rear edges produced into a thin shelf extending over the temporal openings. The occipital process has a thin laterally projecting shelf. The squamosal is produced and extended along its upper surface to form a sharp ridge.

The skull features reflect the need for massiveness and multiple fastenings for the powerful jaw muscles of an animal whose feeding habits demand the crushing of hard objects.

Range.—Turtles of this species have been reported from the Chipola River and from Ichauwaynochaway Creek (tributary of the

Flint River), Baker County, Georgia (Crenshaw and Rabb, 1949) (Fig. 1). A specimen in the Museum of Zoology, University of Michigan (No. 100689) was collected by John W. Crenshaw, Jr., in the Flint River, Newton, Baker County, Georgia, January 28, 1950. This turtle falls within the range of variation observed in the Chipola River population.

Tulane field crews found this turtle abundant in the Chipola River but collected only a single individual from the Escambia River. Intensive collecting in the Pearl River has failed to produce this species. The Alabama and Tombigbee Rivers have not been examined for mapturtles. The distribution may be limited to those river systems from the Escambia to the Apalachicola. No records are available from upper parts of the Gulf Coast river systems but it is believed that turtles are present (Fig. 1).

Growth.—The plastron length of hatchlings is 1.76–3.11 cm., mean 2.59 cm. as calculated from the birth rings of 26 individuals one to three years of age. The calculated sizes for subsequent years are: 1st year, 3.09–5.1, mean 4.36 cm. (38 individuals); 2nd year, 4.94–6.50, mean 5.89 cm. (7); 3rd year, 6.78–9.09, mean 7.86 cm., (5); 4th year, 9.63–10.22, mean 9.93 cm. (2).

The smallest sexually mature male, 6.9 cm. in plastron length, was 2.68 cm. long when hatched, 4.35 at the end of its 1st growing season, 5.33 at the end of the 2nd, 6.33 at the end of the 3rd. It was in the 4th season when collected (July 14, 1951) and had increased 0.57 cm. in plastron length during that season. Of the 105 adult males examined only five retained measurable growth rings. One with a plastron length of 7.02 was in its 3rd growing season and had these plastron lengths: hatching, 2.01; end of 1st season, 3.09; end of 2nd, 5.74. A second turtle in its fourth season had a plastron length of 7.33 cm. and the following growth history: hatching, 2.35 cm.; 1st season, 3.53; 2nd 5.8; 3rd, 6.78. Similarly, another male in its third season had this growth history: hatching, 1.76 cm.; 1st season, 4.25; 2nd, 6.15. Only 21 of the remaining 99 males had any evidence of recent growth. Their plastron lengths ranged from 8.6 to 10.2 cm. The smallest male that showed no evidence of recent growth had a plastron 8.8 cm. long.

Fig. 6. Lateral, dorsal and ventral views of the skull of *Graptemys barbouri* (upper) and *G. pulchra* (lower).

Of 29 females (Pl. 13.0–22.0 cm.) examined by dissection the smallest sexually mature individual had a plastron length of 17.6 cm. Only one female in excess of this length (Pl. 18.2 cm.) had traces of recent growth in the plastral rings. In contrast, juvenile females grew rapidly. Of 37 (Pl. 7.45–15.8 cm.), 23 had measurable growth rings. The growth history of one of these (Pl. 9.84 cm.) could be traced from birth: size at hatching, 1.93 cm.; 1st season, 4.94; 2nd, 6.15; 3rd, 8.13. The growth history of another (Pl. 10.93 cm.) was as follows: 1st season, 4.10 cm.; 2nd, 6.50; 3rd, 9.09; 4th, 10.22. These growth rates are closely comparable to those of the juvenile males. The other 21 showed growth zones for only the season in which they were collected. Of these, one (Pl.

9.4 cm.) had increased 14 mm.; nine in size group 10–11 cm. had increased 2–14 mm.; two in the size range 11–12 had increased 9–10 mm.; six in the size range 12–13 cm. had increased 4–15 mm.; and three in the size range 13–14 had increased 7–21 mm.

Breeding Habits.—Dissection of 25 females in the size range 20.4–25.0 cm. yielded 105 oviducal eggs. Some of the females had deposited earlier clutches since ovulation points (corpus luteum or corpus albicans) were present in excess of the number of oviducal eggs. One female (Pl. 24.0 cm.) had three oviducal eggs and eight ovulation points; another (Pl. 24.2 cm.) had nine oviducal eggs and eighteen ovulation points. Too, additional broods would probably have been deposited. Some females containing oviducal eggs also had 4–33 ovocytes in excess of 1 cm. in diameter. The total number of eggs that each female may have deposited could be determined for seven individuals as follows: Pl. 20.4 cm., 21 eggs; 22.3 cm., 11 eggs; 23.0 cm., 17 eggs; 23.5 cm., 25 eggs; 24.0 cm., 15 eggs; 24.0 cm., 14 eggs; 24.2 cm., 51 eggs. The number of oviducal eggs was 4 to 11.

Of 105 oviducal eggs, 46 had the shell so nearly complete that valid measurements could be made. These were 3.10–4.04, mean 3.71 cm., in length and 2.22–2.93, mean 2.59 cm., in width. The largest eggs (length 3.69–4.04, mean 3.86 cm.; width, 2.65–2.93, mean 2.61 cm.) were removed from the female containing 11 eggs; the smallest eggs (length 3.10–3.68, mean 3.45 cm.; width 2.36–2.55, mean 2.48 cm.) from a female containing six.

Food.—Three quarts of the fecal material of 38 large individuals of both sexes included only fragments of snail shells and an occasional fragment of clam shells. About 95 per cent was composed of broken or entire snail shells.

The Chipola River Population

Hand collecting in the Chipola River, July 12–14, 1950, yielded 393 *Graptemys barbouri*, 2 *Pseudemys scripta scripta*, 1 *Pseudemys floridana mobilensis*, 2 *Sternotherus minor*, and 1 *Macrochelys temmincki*. Observations of turtles on basking sites indicated that *Pseudemys* was somewhat more abundant than suggested by the results of hand collecting. The collecting procedure used (Chaney and Smith. 1950) was undoubtedly selective for *Graptemys*. These turtles were usually grouped in areas of deeper water where basking sites as well as submerged vegetation or debris were present.

Of the 248 individuals from the Chipola River studied in the laboratory, there were 31 juveniles (sex not determined), 105 males, 48 juvenile and 64 adult females. The ratio of females to males was 112:105, not a significant deviation from a 50:50 sex ratio. When sexually mature individuals only are considered, the ratio of females to males is 64:105. Turtles were identified as juvenile females whenever the male secondary sex characteristics were absent in the size range in which males are known to be mature.

The small number of turtles in their first and second season of growth is unusual in a late summer reptile population. This may be a result of the collecting technique as larger turtles appeared to respond more to the stimulus of the outboard motor operation than did the juveniles. Too, the low percentage of such individuals may be attributed to a high mortality rate of juveniles combined with a late egg-laying season. The large females examined had oviducal eggs or enlarged ovocytes still present. None had probably deposited more than one clutch during the season.

The 23 males in the 10–11-cm. size group and many of the females larger than 24 cm. had many signs of old age: deposition of black pigment, development of irregular plastral sutures, thickening and erosion of the carapace and plastron.

The adult females of this population may produce an average of 22 eggs per season (or, if the exceptionally productive female depositing 51 eggs be omitted, 17.1 eggs per season). In this population, then, there was a potential addition by late October of 5.68 hatchlings for every individual present in July.

The Escambia River Population

Collecting in the Escambia River, July 15 and 16, 1950 was difficult because of high water, but six mapturtles were taken. One of these (Tulane 13471) was a large (Pl. 22 cm.) female *Graptemys barbouri* containing eggs. This turtle could not be differentiated from the large females taken in the Chipola River and represents a western extension of the range. The other five turtles were *Graptemys pulchra*. These

differ from those of the Pearl River primarily in the greater irregularity of the markings on the lower jaw.

The Pearl River Population

Hand collecting in the Pearl River and one of its tributary streams, the Bogue Chitto River, produced 110 *Graptemys pulchra* and 58 *G. oculifera*. Of 98 *G. pulchra* collected in the Pearl River, there were 75 juveniles (sex not determined), 12 adult males, 6 juvenile and 5 adult females. In 26 collecting hours along 5.6 miles of the Pearl River, June 1–7, 1950, the following turtles were taken: 64 *Graptemys*, 9 *Pseudemys s. scripta* x *troosti*, 4 *Pseudemys floridana mobilensis*, and 4 *Sternotherus carinatus*.

The sample of *Graptemys pulchra* differs much in composition from that of *Graptemys barbouri* from the Chipola River. There is a great probability that this is only a reflection of the different collecting methods employed.

The Relationships of *Graptemys pulchra* and *G. barbouri*

These two species are similar in color pattern, in general appearance and particularly in that the females develop wide heads and much broadened alveolar surfaces. Characteristics shown by juveniles may be contrasted as follows:

Graptemys pulchra	*Graptemys barbouri*
Postorbital color not extending between horny sheath of upper jaw and eye.	Postorbital color usually extending anteriorly between horny sheath of upper jaw and eye.
Postorbital blotch often with posterior projections; no Y-shaped black mark.	Postorbital blotch without posterior projections; a Y-shaped black mark on rear part of blotch.
Ventral surface of jaw with a longitudinal yellow mark at symphysis.	Ventral surface of jaw with transverse yellow band.
With 13–14 light longitudinal lines on neck from middorsal line to level of angle of jaws.	With 6–7 lines in same region.
Middorsal black line from 1st vertebral along spines and across 4th.	No middorsal line, but spines black or brown tipped.
Semicircular markings on upper surface of marginal wide as 1/5 length of marginal-costal suture.	Semicircular markings present or absent; if present are narrow and no wider than 1/8 length of marginal-costal suture.
Leg band from base of 2nd toe not more than 1½ times width of other leg bands.	Leg band from base of 2nd toe expanded to 2–3 times width of other leg bands.
With 2 or 3 lines on ventral surface of rear leg.	No uninterrupted lines on ventral surface of rear leg; lines broken.
Spines well developed on 2nd, 3rd and 4th vertebrals.	Spines developed on 2nd and 3rd vertebrals; only a low ridge on 4th.
No spine-like projections from pectoral and abdominal scutes at bridge.	Spine-like projections well developed.
Distance between plane of plastron and that of marginal edges one-half or less than length of suture between pectoral and abdominal scutes.	Distance equal to length of suture.

The males retain the color pattern differences shown by the juveniles. The differences in the color markings of the marginals are accentuated. The yellow markings of the males of *G. pulchra* are expanded to form a yellow outer edge on each marginal except the first. These markings are lost in *barbouri* and do not form a yellow outer edge on the marginals.

The females also retain the color pattern differences exhibited in the juveniles. The following is a comparison of two females, *Graptemys pulchra* (Tulane 11900) Cl. 21.5 cm., Pl. 19.5 cm., Cw. 16.5 cm., Hw. 6.75 cm.; *G. barbouri* (Tulane 13879–23) Cl. 25.3 cm., Pl. 22.5 cm., Cw. 18. cm., Hw. 5.7 cm.

The most striking difference is the much greater width of the head in *Graptemys pulchra*. The head width (41 percent of carapace width) lends this specimen an appearance unlike that of any other American species. The spines of the example of *G. barbouri* are more elevated, but this may be due to the fact that it is a younger turtle. Due to its wider posterior marginals the carapace flares posteriorly in *G. barbouri*; this is not true of *pulchra*. In *barbouri* the suture between the 8th and 9th marginal equals the length of the 8th marginal at its outer edge; in *pulchra* the suture is three fourths of this length. The downward projecting lip of the upper jaw is thickened (9 mm.) and abraded in *pulchra*; it is thinner (6 mm.) and sharp edged in *barbouri*. The skulls of these forms are essentially similar.

The similarity of these two species in many aspects of their morphology and ecology, their differences from other members of the genus,

and the pattern of their distribution suggest that they have evolved from a common form, each becoming modified during an unknown period of isolation. Comparison of the intestinal contents of the specimens of *Graptemys barbouri* and *G. pulchra* from the Escambia River suggests that they may be different in their food preferences. The intestine of *barbouri* contained snail shells almost exclusively; that of *pulchra* almost exclusively clam shells.

Research in progress on the structure of the skulls and the ecology of these turtles promises to furnish material essential to an interpretation of their origin and evolution. The ranges are inadequately defined. Workers in Alabama and Georgia can contribute much needed information by collecting turtles of these species.

Literature Cited

Baur, G. 1893. Two new species of North American testudinata. *Amer. Nat., 27: 675–6.*

Beyer, George E. 1900. Check-list of the batrachians and reptiles of Louisiana. *Proc. La. Soc. Nat., 1897–1899: 33–46.*

Cagle, Fred R. 1946. The growth of the slider turtle, *Psuedemys scripta elegans. Amer. Midl. Nat., 36 (3): 685–729.*

Carr, Archie F. 1949. The identity of *Malacoclemmys kohnii* Baur. *Herpetologica, 5 (1): 9–11.*

——— 1952. Handbook of turtles, the turtles of the United States, Canada, and Baja California. *Cornell University Press, Ithaca, N. Y.: XV + 1–542.*

——— and Lewis J. Marchand. 1942. A new turtle from the Chipola River, Florida. *Proc. New Eng. Zool. Club, 20: 95–100.*

Chaney, A. H., and Clarence L. Smith. 1950. Methods for collecting mapturtles. Copeia *(4): 323–4.*

Crenshaw, John W. Jr., and George B. Rabb 1949. Occurrence of the turtle *Graptemys barbouri* in Georgia. Copeia *(3): 226.*

Smith, Hobart M. 1946. The map turtles of Texas. *Proc. and Trans. Texas Acad. Sci., 30: 60.*

Department of Zoology, Tulane University, New Orleans, Louisiana

Thyroxin-Induced Metamorphosis of the Neotenic Salamanders *Eurycea tynerensis* and *Eurycea neotenes*

James Kezer

One of the interesting apsects of recent work on the plethodontid salamanders has been the discovery of a number of neotenic species within this family. Prior to the finding of *Eurycea neotenes* by Bishop and Wright in 1936, the only known neotenic member of the Plethodontidae was the Texas blind salamander, *Typhlomolge rathbuni*. Since that time the discovery of neotenic plethodonts has proceeded with rapidity; a total of eight species, apparently unable to metamorphose under natural conditions, are now known.

Five of these occupy restricted areas at the eastern edge of the Edwards Plateau in central Texas (*Eurycea neotenes*, *E. nana*, *E. latitans*, *E. pterophila* and *Typhlomolge rathbuni*); two inhabit portions of the Ozark uplift in Oklahoma, Arkansas, Kansas and Missouri (*Eurycea tynerensis* and *Typhlotriton nereus*); the remaining species, the amazing *Haideotriton wallacei*, is known from a single specimen taken from a well in Dougherty County, Georgia. To this list of neotenic species there must be added the neotenic specimens of *Eurycea multiplicata* discovered by Dundee (1947) in a small stream in Cherokee County, Oklahoma, and also those mentioned by Bishop (1944). The predominating presence of members of the genus *Eurycea* is evident in this list and it is interesting to observe that four of these neotenic species (*Eurycea latitans*, *Typhlotriton nereus*, *Typhlomolge rathbuni* and *Haideotriton wallacei*) show varying degrees of adaptation to the cave habitat.

In order to understand clearly the taxonomic situation regarding these neotenic species, it is well to remember that some of them are very closely related. This is particularly true of *Eurycea neotenes*, *E. latitans* and *E. pterophila*. Moreover, *Typhlotriton nereus* can be distinguished only with difficulty from larvae of the Ozark blind salamander, *T. spelaeus*. Regardless of the ultimate taxonomic fate of some of these salamanders, their discovery has called atten-

tion to a very real and considerable neoteny within the Plethodontidae and has pointed to the desirability of experimental work in order to determine the cause of the failure of metamorphosis in these forms.

The work of Gudernatsch (1912, 1913–14) established the thyroid hormone as the agent responsible for amphibian metamorphosis. Subsequently a large and intensely interesting body of literature has accumulated dealing with normal and experimentally induced metamorphosis in the Amphibia. (A helpful bibliography of the important papers on this subject has been prepared by Adams (1949).) Although the thyroid hormone is the fundamental agent responsible for the metamorphosis of an amphibian in the normal physiology of the animal, it was determined through a series of ingenious experiments that metamorphosis could be induced by a variety of substances, all of them, however, related in one way or another to the thyroid hormone. The amino acid thyroxin was shown to be one of the best of the metamorphosing agents in terms of its ability to bring the animal alive through the period of metamorphosis. In all probability this is at least partially to be explained by the precision with which the concentration and administration of thyroxin can be controlled.

It might be supposed that with a knowledge of the hormone responsible for amphibian metamorphosis the problems involved in amphibian neoteny would be very quickly solved. However, this was not the case; amphibian neoteny, like other biological problems, proved to be highly complex. Experimental attempts at the complete metamorphosis of the perennibranch salamanders such as *Pseudobranchus*, *Siren*, *Necturus* and *Cryptobranchus* met with failure; most of the tissues of these amphibians were shown to be insensitive to the thyroid hormone. Other groups of amphibians were investigated in which occasional individuals failed to metamorphose at the usual time for the species, these physiological variants becoming sexually mature as larvae. Neotenes of this type readily metamorphosed when they were treated with the proper metamorphosing agents or, as in certain strains of *Ambystoma tigrinum*, when they were merely subjected to a change in environment. These curious cases of endocrine instability are at present incompletely understood although the work of Ingram (1928, 1929) suggests that the explanation may lie in a defective relationship between the anterior lobe of the pituitary and the thyroid.

The perennibranch salamanders, as well as those in which neotenous individuals occasionally appear, have good thyroid glands capable of inducing metamorphosis when they are implanted in other larval amphibians. A unique situation prevails in the Texas blind salamander, *Typhlomolge*, which, alone among the vertebrates, lacks functional thyroid glands. This remarkable fact was first established by Emerson (1905) and later verified by Uhlenhuth (1923) who found only undifferentiated epithelial rudiments replacing, in *Typhlomolge*, the normal salamander thyroid. The ability of the tissues of this highly modified salamander to respond to the thyroid hormone has never been determined and the rarity of *Typhlomolge* in the caves of the Edwards Plateau around San Marcos, Texas, indicates that there will be very little opportunity for experimental work of that kind.

In order to understand the cause of metamorphosis failure in those neotenic plethodonts that are available in sufficient quantity for experimentation, it is first necessary to determine the sensitivity of their tissues to metamorphosing agents. The question is whether these salamanders are entirely incapable of metamorphosis, as in the perennibranchs, or whether their tissues are able to respond to the thyroid hormone and related substances, as in the neotenic newts and ambystomid salamanders. This question has been answered for *Eurycea neotenes* and *E. tynerensis* by experiments in which these salamanders were subjected to the influence of dilute solutions of thyroxin.

The specimens of *Eurycea tynerensis* that were used in the experiment were collected at the type station, Tyner Creek near Proctor, Oklahoma, with the generous help of Dr. George A. Moore and several of his students. The salamanders, secured during the first week of April, 1942, were transported to Ithaca, New York, and kept in tap water at room temperature until the beginning of the experiment on April 19. On this date, four specimens of *E. tynerensis* were placed in individual finger bowls, each of which contained 25 cc. of a 1:500,000

thyroxin solution that was changed at approximately two day intervals. (The stock thyroxin solution was prepared by dissolving 1 mg. of crystalline thyroxin in 10 cc. of distilled water to which a drop of 1 percent NaOH was added; this stock was kept in a refrigerator and diluted as needed.) On April 29, ten days after the beginning of the experiment, all four of the experimental animals showed metamorphic changes: their gills were reduced, skin was being shed and they tended to remain out of the thyroxin solution on rocks that had been placed in the finger bowls. By May 6 the metamorphosis of the four treated animals seemed to be complete. The gills were gone, the skull shape had changed, eyelids had developed and the eyes bulged out from the head, the tail fin had disappeared and the salamanders remained continuously out of the solution. (Plate I, figs. 3–6.) Control animals, maintained in the laboratory in tap water, showed no metamorphic changes. The experimental animals were kept alive until the latter part of May when it became necessary to discontinue the observations.

Experiments with *Eurycea neotenes* gave results similar to those provided by *E. tynerensis*. The specimens used were obtained through the kindness of Professor and Mrs. A. H. Wright who collected them at Cherry Springs and Walnut Springs, West Fork of Cibola Creek, Bexar County near Bracken, Texas, on January 18, 1942. The five animals that arrived alive in Ithaca were kept in a refrigerator until the beginning of the experiment on February 20. The small number of specimens made it necessary to experiment with only a single animal. The treatment given this salamander was similar to that outlined for *tynerensis* except that the thyroxin solution employed at the beginning of the experiment was diluted 1:1,000,000 and changed seven days later to a 1:500,000 dilution. On March 7 the reduction of the gills and the shedding of skin indicated that metamorphosis was taking place. By March 11, all external aspects of metamorphosis appeared to have been completed. (Plate I, figs. 1–2.) During this time, no metamorphosis took place in the four controls.

In terms of the nature of their neoteny, *Eurycea tynerensis* and *E. neotenes* form a new category of salamanders that fail to metamorphose; they can be placed neither with the perennibranchs nor with the newts and ambystomid salamanders in which occasional neoteny is found. Utilizing the data available at this time, it is possible to group the neotenic salamanders as follows. (1) The perennibranchs in which natural metamorphosis completely fails to occur and in which experimentally induced metamorphosis has not been successful. The thyroid glands are present and physiologically active. Metamorphosis fails because most of the tissues are insensitive to the action of the thyroid hormone. (2) The plethodontid salamanders, *Eurycea tynerensis* and *E. neotenes*, which, like the perennibranchs, apparently never metamorphose under natural conditions but, unlike the perennibranchs, are easily metamorphosed by treatment with dilute thyroxin solutions and presumably by other metamorphosing agents. Nothing is known at present about the histological or physiological condition of the thyroid gland in these species. No data are available to explain the cause of this neoteny but the idea of a defective relationship between pituitary and thyroid is highly suggestive. (3) The various species of newts and ambystomid salamanders in which metamorphosis may or may not occur, oftentimes depending upon environmental circumstances. All of the species that have been investigated are capable of experimental metamorphosis. They possess histologically normal thyroid glands that are able to induce metamorphosis when implanted in other immature amphibians. Although the cause of this neoteny is not understood, an unstable relationship between the pituitary and thyroid is again a highly suggestive approach. (4) A fourth category must be provided to accomodate *Typhlomolge rathbuni*, the only known vertebrate without a thyroid gland. Until the sensitivity of the tissues of *Typhlomolge* to metamorphosing agents has been determined, it is impossible to put all of the blame for the neoteny of this species upon its deficient thyroid apparatus. But under any circumstances, the lack of thyroid glands provides the Texas blind salamander with a distinctive position and requires that it be separated from the other three groups of salamanders in which neoteny is shown.

Much remains to be learned regarding this curious failure of metamorphosis within the Plethodontidae. A comparison of the histo-

logical structure of the thyroid glands of the neotenic species with the thyroids found in closely related non-neotenic species must now be made. The metamorphosing potency of the thyroids of the neotenic species when these glands are implanted in immature amphibians needs to be determined. The possibility of the cause of the neoteny residing in a deficient relationship between anterior lobe of the pituitary and thyroid gland must also be investigated. Experimental investigations conducted with these species may very well solve problems that could not be satisfactorily studied with the newts and ambystomid salamanders in which only partial neoteny is shown within a particular species. Indeed, it is even possible that these interesting plethodonts may prove to be the best material yet found for the experimental study of amphibian neoteny.

Dr. Robert Barden provided the transportation from New York to Oklahoma for the trip on which the specimens of *Eurycea tynerensis* were collected and he also provided space and facilities for conducting the experiments in his laboratory at Cornell University. Mr. Arthur L. Smith made the photographs. Miss Margaret G. Bradbury retouched several of the photographs and prepared the plate. The kind and generous help of these three friends is deeply appreciated. The crystalline thyroxin used in the experiments was supplied through the courtesy of Roche-Organon, Inc., Nutley, N. J.

Literature Cited

(In addition to the literature specifically cited in the text, the bibliography contains the titles of papers in which the neotenic members of the Plethodontidae were first described.)

Adams, Elizabeth A. 1949. Studies in experimental zoology. Third edition. *Edwards Brothers, Inc., Ann Arbor, Michigan: xiv + 120 pp.*

Bishop, Sherman C. 1941. Notes on salamanders with descriptions of several new forms. *Occ. Papers Mus. Zool. Univ. Mich., 451: 1–27. [Eurycea nana]*

——— 1944. A new neotenic plethodont salamander, with notes on related species. Copeia *(1): 1–5. [Typhlotriton nereus]*

Bishop, S. C., and Margaret R. Wright. 1937. A new neotenic salamander from Texas. *Proc. Biol. Soc. Washington 50: 141–144 [Eurycea neotenes]*

Burger, W. Leslie, Hobart M. Smith and Floyd E. Potter, Jr. 1950. Another neotenic *Eurycea* from the Edwards Plateau. *Proc. Biol. Soc. Washington 63: 51–68. [Eurycea pterophila]*

Carr, A. F. 1939. *Haideotriton wallacei*, a new subterranean salamander from Georgia. *Occ. Papers Boston Soc. Nat. Hist., 8: 333–336.*

Dundee, Harold A. 1947. Notes on salamanders collected in Oklahoma. Copeia *(2): 117–120.*

Emerson, Ellen T. 1905. General anatomy of *Typhlomolge rathbuni. Proc. Boston Soc. Nat. Hist., 32: 43–76.*

Gudernatsch, J. F. 1912. Feeding experiments on tadpoles. I. *Arch f. Entwmech., 35: 457–83.*

——— 1913–14. Feeding experiments on tadpoles. II. *Amer. Jour. Anat., 15: 431–82.*

Ingram, W. R. 1928. Interrelation of pituitary and thyroid in metamorphosis of neotenic amphibians. *Proc. Soc. Exp. Biol. Med., 25: 730–31.*

——— 1929. Studies of amphibian neoteny II. The interrelation of thyroid and pituitary in the metamorphosis of neotenic anurans. *Jour. Exp. Zool., 53: 387–409.*

Moore, George A., and R. Chester Hughes. 1939. A new plethodontid from eastern Oklahoma. *Amer. Midl. Nat., 22: 696–99. [Eurycea tynerensis]*

Smith, Hobart M., and Floyd E. Potter, Jr. 1946. A third neotenic salamander of the genus *Eurycea* from Texas. *Herpetologica 3: 105–109. [Eurycea latitans]*

Stejneger, Leonhard. 1896. Description of a new genus and species of blind tailed batrachian from the subterranean waters of Texas. *Proc. U. S. Nat. Mus., 18: 619–621. [Typhlomolge rathbuni]*

Uhlenhuth Eduard. 1923. The endocrine system of *Typhlomolge rathbuni. Biol. Bull., 45: 303–324.*

Department of Zoology, University of Missouri, Columbia, Missouri.

Growth and Maturity of the Three Species of *Thamnophis* in Michigan

Charles C. Carpenter

Very few studies have been made of growth in snakes, and only since the development of methods of marking them individually have adequate data on growth been gathered. Blanchard and Finster (1933) compiled data on the common gartersnake and the common watersnake in northern Michigan. Growth in the plains gartersnake and the

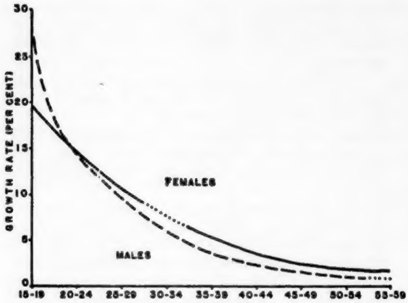


Fig. 1. Changes of growth rate with age in the common gartersnake. Rate is expressed in percentage increase in body length per growing month (May–September). Dotted line indicates no data.

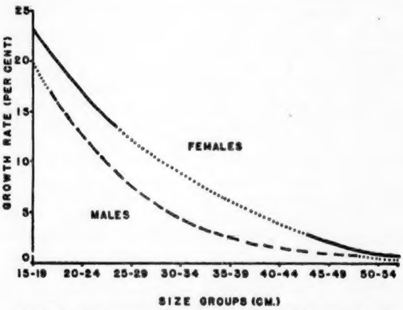


Fig. 2. Changes of growth rate with age in the ribbonsnake. Rate is expressed in percentage increase in body length per growing month (May–September). Dotted line indicates no data.

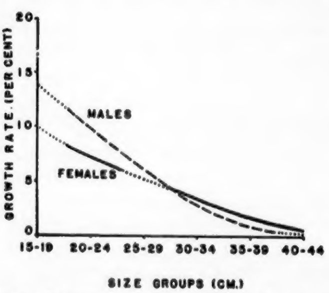


Fig. 3. Changes of growth rate with age in the Butler's gartersnake. Rate is expressed in percentage increase in body length per growing month (May–September). Dotted line indicates no data.

smooth greensnake was discussed by Seibert and Hagen (1947), while Fitch (1949) and Hayrend and Call (1951) have investigated growth of the Pacific rattlesnake and the Great Basin rattlesnake respectively.

As a part of an ecological study of the Michigan gartersnakes, the common gartersnake (*Thamnophis s. sirtalis*), the ribbonsnake (*Thamnophis s. sauritus*), and Butler's gartersnake (*Thamnophis butleri*), near Ann Arbor, Michigan, a large amount of growth data were gathered between 1948 and 1950.

All snakes were marked by clipping the caudal scutes. Growth was determined from measurements of repeated captures. Measurements were made in the field. Both body length (tip of rostrum to end of anal scale) and total length (tip of rostrum to tip of tail) were measured, but only body lengths were used for determining growth, because part of the tail was often gone. The error in measurement was estimated by comparing a series of measurements on the same individual. This error was not more than 1 cm.

The period of growth, as indicated by the data, does not include the entire activity period (time between emergence from and entrance into hibernation), but is generally limited to the warmer months of the year. For computations, the growth period for all three species is considered to be the five months from May through September (153 days). Records before and after this period indicate no significant growth. This agrees with Blanchard and Finster's (1933) findings in northern Michigan.

All three species of garternsakes show a similar pattern of growth. There is an actually greater increase per growing month in the smaller snakes which results in a much greater percentage increase of body length per month. The percentage increase in length per growing month was obtained by dividing the increase between captures by the length of the snake at the beginning of the period and then dividing by the number of elapsed growing months. Individual variation in growth is sometimes very great and the data are expressed in averages. The common gartersnake, for which the most data were available, exhibits a consistent decrease in growth rate as the animal becomes larger (Fig. 1). For the ribbonsnake and Butler's gartersnake, the same pattern of decrease is indicated from fewer records (Figs. 2 and 3).

Both males and females grow rapidly for the first year, but the growth rate of the male de-

creases faster. This differential growth rate results in an adult group of females averaging larger than the corresponding group of males (Figs. 4–6). The total lengths of the females also average greater than those of the males even though the males have a proportionately longer tail. The young of the year are easily separated as a distinct group in the fall, and the following spring they are still isolated (Figs. 4–6). During the summer, these juveniles 12–30 percent. A large male increased 0.2 percent and a large female 2 percent. Small ribbonsnakes varied from 13 to 29 percent while a large male increased 0.43 percent and a large female 2 percent. The variation for small Butler's gartersnakes was 7–10 percent; a large male increased 0.56 percent, a large female, 3 percent.

Correlations between size and age of the three species of snakes were obtained by use of

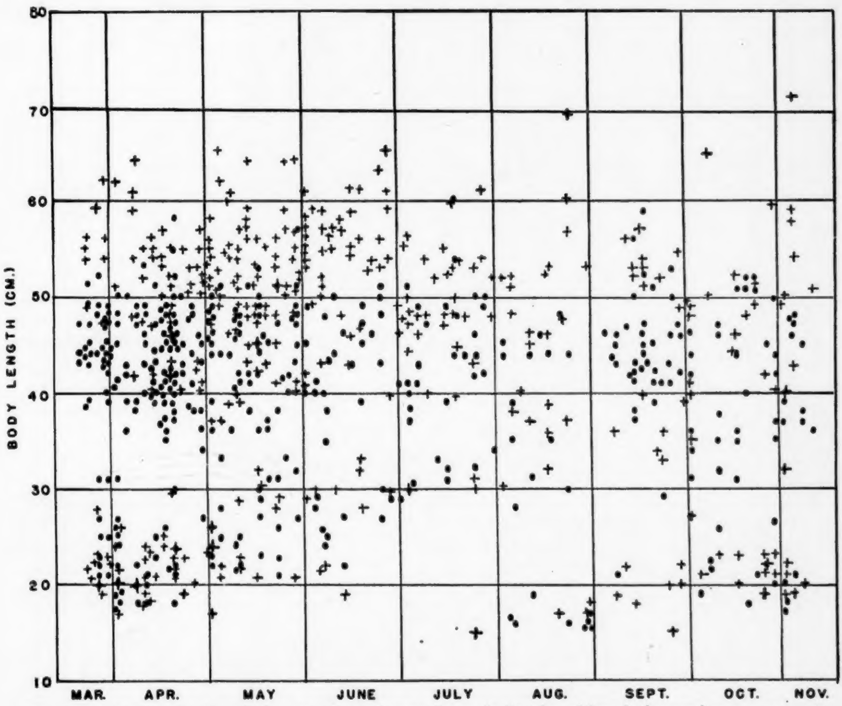


Fig. 4. Body lengths in relation to time of year for male (dots) and female (crosses) common gartersnakes near Ann Arbor, Michigan, 1948–1950.

approach the size of the older snakes so that by fall they form essentially the lower part of this older group. Among the adults it is not possible to sèparate successive age groups, probably because of the great variations in individual growth.

This variation is shown by several individuals of different sizes recaptured after a period of approximately five growing months. Small males of the common gartersnake showed an increase in body length per growing month of estimated growth curves. Adults of both sexes of the three species with equal body lengths are generally not of the same age (Fig. 7).

Because there has been much speculation as to the age at which gartersnakes reach maturity, attention was directed toward obtaining pertinent data. As early as the first of May, developing embryos could be detected in many females by working the fingers along the ventral side of the snake. This method was used as a test for pregnancy in all females captured from June

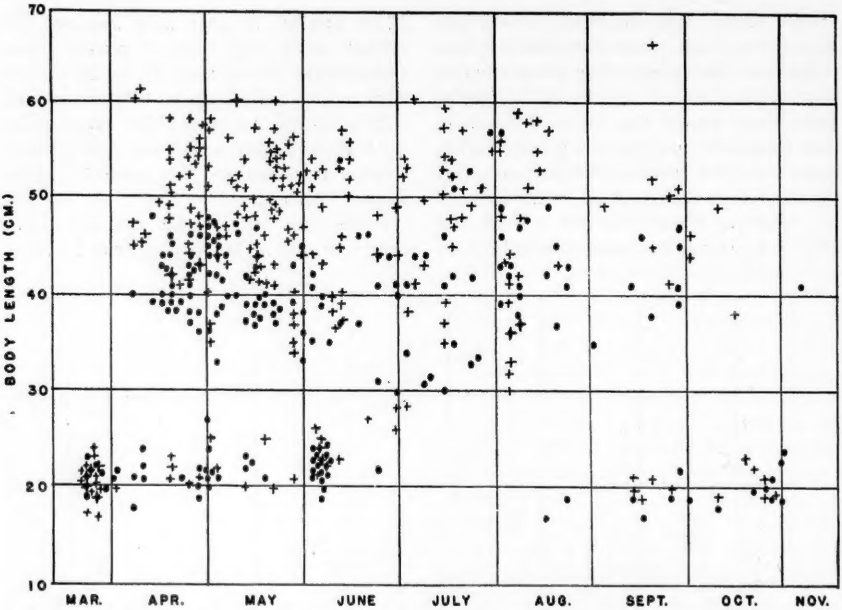


Fig. 5. Body lengths in relation to time of year for male (dots) and female (crosses) ribbonsnakes near Ann Arbor, Michigan, 1948–1950.

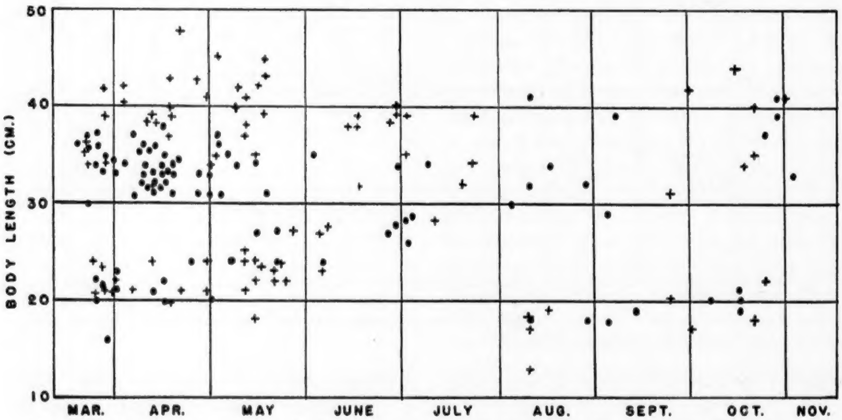


Fig. 6. Body lengths in relation to time of year for male (dots) and female (crosses) Butler's gartersnakes near Ann Arbor, Michigan, 1948–1950.

through September. Growth and age data from recaptured snakes show that two-year-old females of all three species may produce young.

A female ribbonsnake, with a body length of 19.8 cm. on May 16, 1949, was recaptured on May 10, 1950; she had grown to 46.6 cm. and contained developing embryos. She had undoubtedly been born in the summer of 1948 and had reached maturity in her second season of growth. Though gartersnakes sometimes mate in the fall, this one had probably mated in her second spring when less than two years

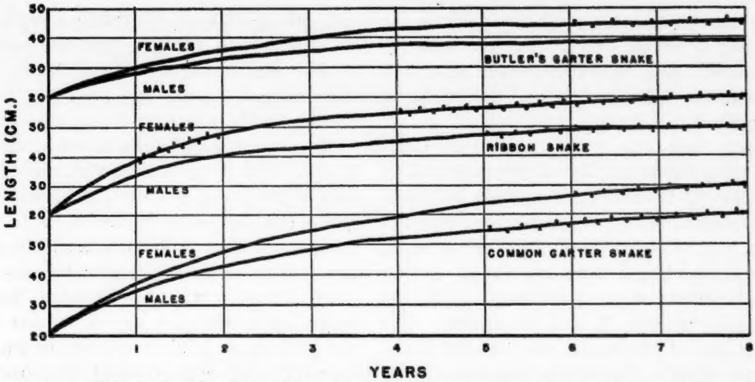


Fig. 7. Age and body length relationships of gartersnakes near Ann Arbor, Michigan. Curves formed from estimated hypothetical body length of 20 cm. at birth and calculation of theoretical annual increase in length. Data of Tables I–III were used for these calculations, and in some instances, these figures were chosen to fit a descending scale. Dotted portions of curves represent assumed projections where no data were available. Snakes of these large sizes have been recorded, but none was recaptured for growth data.

TABLE I

GROWTH RATE OF THE COMMON GARTERSNAKE

Initial body length in cm.	Females			Males		
	Number of snakes	Increase, cm./mo.	Increase per mo. (%)	Number of snakes	Increase, cm./mo.	Increase per mo. (%)
15–19	2	3.28	17.60	2	3.69	25.88
20–24	2	3.42	16.19	7	3.12	13.98
25–29	1	2.86	9.70	5	2.85	10.66
30–34	..	...	...	3	2.23	7.28
35–39	1	3.98	10.60	12	1.11	3.09
40–44	3	2.17	5.01	20	1.05	2.52
45–49	13	1.26	2.42	27	0.66	1.43
50–54	21	0.90	1.73	8	0.41	0.84
55–59	15	1.17	1.76	..	...	...
60–64	1	0.70	1.16	..	...	...

TABLE II

GROWTH RATE OF THE RIBBONSNAKE

Initial body length in cm.	Females			Males		
	Number of snakes	Increase, cm./mo.	Increase per mo. (%)	Number of snakes	Increase, cm./mo.	Increase per mo. (%)
15–19	2	3.93	22.21	..	...	...
20–24	5	5.03	24.12	5	2.43	12.16
25–29	..	...	...	1	2.14	7.25
30–34	..	...	...	1	0.89	2.67
35–39	..	...	...	8	1.50	3.98
40–44	..	...	...	5	0.58	1.41
45–49	13	1.13	2.36	5	0.47	1.04
50–54	15	0.43	0.81	..	...	...

old. Altogether, eleven other gravid females of this species were shorter than 46.6 cm.; the smallest was 42.1 cm., captured May 18, 1950. According to growth records, it is possible that many female ribbonsnakes reach mature size at two years, and the above observations tend to corroborate this assumption.

There were no records of gravid female common gartersnakes captured in their first full year of growth, but based on growth data, it is a logical deduction that many females reach a body length as great as 45 cm. by the end of that period. The shortest length for a gravid female of this species, captured June 17, 1949, was 42.6 cm. Three others with body lengths

less than 48 cm. were recorded as gravid. By comparing known size at maturity with the estimated age as shown by growth data, it is possible to determine the age of a snake at maturity.

M. D. Burt (1928: 9–10) dissected 43 females (all taken before the time of parturition) from the Douglas Lake region of northern Michigan. She found no embryos in females less than 551 mm. in total length. C. E. Burt (1928) found that the tail length of females ranged from 18 to 25 percent of the total length, with the majority between 21 and 24 percent. This latter span of percentage, when applied to the 55-cm. criterion (approximate minimum mature size given by M. D. Burt), gives a range

TABLE III
GROWTH RATE OF BUTLER'S GARTERSNAKE

Initial body length in cm.	Females			Males		
	Number of snakes	Increase, cm./mo.	Increase per mo. (%)	Number of snakes	Increase, cm./mo.	Increase per mo. (%)
15–19	..	...	...	..	...	...
20–24	1	1.15	7.00	2	1.92	8.85
25–29	..	...	...	1	2.93	10.80
30–34	2	1.24	3.59	7	0.80	2.50
35–39	2	0.55	1.52	3	0.18	0.51
40–44	3	0.20	0.46	..	...	...

of body lengths of 41.80–43.45 cm. In the present study many of the second-spring females recorded fall within this range. Pope (1947) listed the smallest gravid female on record at 19⅛ inches (48.5 cm.). If it is assumed that this female has the shortest tail ratio (21 percent), it then had a body length of approximately 38 cm., which is well within the range of second spring females.

The smallest gravid female of Butler's gartersnake had a body length of 34.5 cm., and two others measured 34.8 and 35.8. They fall within the size range reached by females of this species in their second spring (Fig. 6). Pope's (1947: 205) smallest female parent had a total length of 16⅝ inches (43 cm.). If the tail ratio given by Davis (1932) is applied (20 to 23 percent for females), then this snake had a body length of approximately 32 cm. From this evidence it seems that some two-year-old females of this species produce young.

The mature size of males at sexual maturity is more difficult to determine because the feature of pregnancy is absent, but some indication of this size can be obtained in the following manner. Harrison (1933) determined, by use of the knobbed anal keels, a secondary sex character of male common gartersnakes, that the approximate minimum size of mature males was 47.5 cm., or a minimum body length of 37 cm. (tail ratio of 22 per cent). Blanchard and Blanchard (1942) recorded a male common gartersnake of 50 cm. (total length) as fathering a brood. Again, using the tail ratio of 22 to 26 percent, this snake had a body length of about 38 cm. A male of this species with a body length of 39.2 cm. was recorded in courtship on April 16, 1950. Another male, captured on October 26, 1948, measured 21.5 cm. in body length (obviously born that summer) and when recaptured on April 16, 1950, it measured 39.2 cm. From this evidence, it is readily seen that at least some males of the common gartersnake reach sexual maturity the second spring after birth and before they are two years old.

For the ribbonsnake and Butler's gartersnake, evidence is scanty. On April 4, 1950, a male Butler's gartersnake with a body length of 32.1 cm. was observed courting a larger female. This size is within the range of males the second spring after birth. It is probable that male ribbonsnakes mature as quickly as the females, though there are no data to substantiate this assumption.

The number of small females that were gravid was few, and because of individual variation in growth, it is probable that many individuals of both sexes of the three species do not reach mature size until approximately their third spring after birth.

LITERATURE CITED

BLANCHARD, F. N., AND F. C. BLANCHARD. 1942. Mating of the garter snake *Thamnophis sirtalis sirtalis* (Linnaeus). *Papers Michigan Acad. Sci. Arts. Let., 27: 215–34.*

BLANCHARD, F. N., AND E. B. FINSTER. 1933. A method of marking living snakes for future recognition, with a discussion of some problems and results. *Ecol., 14: 334–47.*

Burt, C. E. 1928. Sexual dimorphism in the tail length of the Common Garter Snake, *Thamnophis sirtalis sirtalis* (Linnaeus). Copeia, *166: 13–14.*

Burt, M. D. 1928. The relation of size to maturity in the garter snakes, *Thamnophis sirtalis sirtalis* (L.) and *Thamnophis sauritus sauritus* (L.) *Ibid., 1 66: 8–12.*

Davis, D. 1932. Occurrence of *Thamnophis butleri* (Cope) in Wisconsin. *Ibid.* (*3*)*: 113–18.*

Fitch, H. S. 1949. Study of snake populations in central California. *Amer. Midl. Nat., 41: 513–79.*

Harrison, M. B. 1933. The significance of knobbed anal keels in the garter snake, *Thamnophis sirtalis sirtalis* (Linne). Copeia (*1*)*: 1–2.*

Heyrend, F. L., and A. Call. 1951. Growth and age in Western Striped Racer and Great Basin Rattlesnake. *Herpetologica, 7: 28–40.*

Pope, C. H. 1947. Amphibians and reptiles of the Chicago area. *Chicago Nat. Hist. Mus. Press, Chicago: 1–275.*

Seibert, H. C., and C. W. Hagen, Jr. 1947. Studies on a population of snakes in Illinois. Copeia (*1*)*: 6–22.*

Department of Zoology, University of Michigan, Ann Arbor, Michigan.

Life History and Ecology of the Sculpin *Cottus bairdi punctulatus* in Southwestern Montana[1]

Jack E. Bailey

Introduction

An investigation of the life history and ecology of the Rocky Mountain mottled sculpin, *Cottus bairdi punctulatus* (Gill), was started in January, 1950, and continued until October, 1951. This study was centered mainly on the West Gallatin River in the vicinity of Shedds Bridge, 5½ airline miles downstream from the village of Gallatin Gateway, Gallatin County, Montana. During the summer of 1950, observations were made on the sculpins of Prickley Pear Creek which empties into the Missouri River about six miles upstream from Craig, in Lewis and Clark County. The area studied included the lower 13 miles of Prickley Pear Creek and the lower 1½ miles of Wolf Creek, which is a small tributary thereto.

Description of the Sampling Areas.—The West Gallatin collecting station was 2300 feet long. The maximum width of this section during flood stage (May–June) was approximately 150 feet and the maximum depth approximately 8 feet. In September, 1951, at the low water period, the maximum width was approximately 70 feet. Practically all of the collections were made in water between the shoreline and the 2-ft contour, neither of which occupied fixed positions as their locations were dependent on water levels. In 1951, the water level dropped approximately three feet from its flood stage peak in May to near normal summer level recorded June 10. This caused the shoreline to move in as much as 100 feet in certain places. By September 17, the water level was down another 6 inches. Gradients of the sampling section were measured with a hand level at 100-foot intervals. The mean gradient for the section was 0.70 foot per 100 feet with a maximum of 1.94 and a minimum of 0.22. The maximum surface velocity measured, in the area where sculpins were collected, was 4.6 feet per second. Bottom materials in the sampling area consisted of approximately 30 percent boulders, 55 percent rubble, and 15 percent sand and gravel. Both banks of the section are bordered by cottonwoods, aspens and willows. Algae was the only abundant aquatic vegetation.

Water temperatures for the West Gallatin station were taken at irregular intervals throughout the collecting period, usually between 2:30 and 3:30 pm. Minimum temperatures (32–36°F.) occurred during December, January, February and March of both years with a definite "warm up" period beginning in late March. No temperatures were taken in the summer of 1950 but in 1951 the maximum temperature of 65°F. occurred on July 31.

In Prickley Pear Creek, sculpins were collected in riffle areas which had a maximum summer width of approximately 45 feet and a

[1] Contribution from Montana State College, Agricultural Experiment Station. Project No. MS844-42, Paper No. 255, Journal Series.

minimum of 21 feet. The maximum depth varied from 14 inches over shallow riffles to about 8 feet in deep pools during September, 1950. The maximum surface velocity recorded during September was 4.3 feet per second in areas where collections were made. Bottom materials of riffle areas varied greatly but rubble was predominant, with mixtures of gravel, sand and boulders. Pool bottoms were mostly of clay or sand. After the spring runoff, green algae and white water-crowfoot (*Ranunculus aquatilis*) became abundant and persisted through most of the summer. The minimum water temperature for the period June 9 to September 27 was 43°F. (June 9), and the maximum was 67°F. (July 26). Variations in temperatures throughout any 24-hour period ranged from 3° to 16°F.

Wolf Creek is similar to Prickley Pear Creek except that it is much smaller. On June 17, 1950, the maximum width was 38 feet and the maximum depth in riffle sections was 18 inches.

Fish Associates.—The sculpin (*Cottus bairdi punctulatus*) was the most abundant fish in the sampling area on the West Gallatin River. Brown trout (*Salmo trutta*), rainbow trout (*Salmo gairdneri*), cutthroat trout (*Salmo clarki*), rainbow-cutthroat hybrids, brook trout (*Salvelinus fontinalis*), mountain whitefish (*Prosopium williamsoni*), longnose sucker (*Catostomus catostomus*), white sucker (*Catostomus commersoni*), and longnose dace (*Rhinichthys cataractae*) are known to occur in the same general area. Except for the suckers, all of the above species were observed in the sampling area. Suckers may have been present but no attempt was made to collect them.

The sculpin was also the most abundant fish in both Prickley Pear Creek and Wolf Creek. (One albino sculpin with a total length of 62 mm. was found in Wolf Creek.) Associated species of trout, whitefish and suckers were the same as in the West Gallatin River. Carp (*Cyprinus carpio*) and Eastern burbot (*Lota lota lacustris*) were present in small numbers in Prickley Pear Creek.

Acknowledgments.—Thanks are extended to those who assisted in this study. Dr. C. J. D. Brown suggested and directed the investigation and assisted in the preparation of the manuscript. Observations on time of spawning and incubation period of sculpins from the West Gallatin River during the 1950 summer season were made by George Holton. Raymond Hays gave many hours of valuable assistance in the determinations of food organisms. Charles K. Phenicie, fishery biologist for the Montana State Fish and Game Department, furnished the electric shocking equipment for making collections and assisted in the analysis of certain data. The species of sculpins from the West Gallatin River and Prickley Pear Creek were determined by Dr. Leonard P. Schultz. The writer wishes to express appreciation to fellow students who helped in making collections.

Collection and Preservation.—Most collections of sculpins were made with a screen 3 by 4 feet similar to that described by Needham and Needham (1941). The screen was held in an inclined position against the stream bottom, and the rubble and gravel immediately upstream was dislodged by kicking. Sculpins that collected on the screen were lifted from the water. This method was adequate for small samples of all sculpins except those less than 20 mm. in total length. Small sculpins were most abundant in shallow, slow water and were more readily collected with a tea strainer. The collecting screen and the tea strainer were both provided with screen having 16 mesh per linear inch. Two electric shockers were used for taking large samples. One was a 500-watt, AC generator used at voltages of 160 to 200, and the other a 250-watt, DC generator used at 125 volts. Each machine was equipped with two portable electrodes. The DC generator appeared to be more efficient on the larger sculpins. The positive electrode of the DC shocker was manipulated so as to attract sculpins upwards from the stream bottom thus making it easy to recover them. Sculpins shocked by alternating current were more subject to the flow of the stream which often carried them under rocks where they lodged out of sight. The smaller sculpins were easily collected because they remained near shore where water currents were not effective in carrying them under rocks.

The majority of sculpins collected were preserved in 10 percent formalin at the time of capture. However, when otoliths were to be taken, specimens were weighed and measured in fresh condition. The relationship between

total lengths of fresh and preserved sculpins was determined for a sample of 75 specimens. The fresh total lengths ranged from 60 to 121 mm. These fish were then placed in 10 percent formalin for 3 months and measured again. Total lengths after preservation ranged from 57 to 115 mm. The resulting formula for conversion from fresh total length (Y) in mm. to total lengths of preserved fish (X) in mm. was $X = 0.960Y$. When converting from preserved to fresh total lengths, the formula becomes $Y = 1.037X$. Similar factors were obtained for 101 small sculpins (fresh total lengths, 25–42 mm.). The conversion factor from fresh to preserved total length for this sample was 0.990 and from preserved to fresh total length was 1.010.

Food Habits

Twenty-three collections were obtained from the West Gallatin River and three from Prickley Pear Creek to determine food habits. No definite collecting schedule was followed except to secure at least one sample for each calendar month. Collecting began January 21, 1950, and ended August 31, 1951. Almost all collections were made in the afternoon. A total of 903 specimens was examined, 821 from the West Gallatin River and 82 from Prickley Pear Creek. The West Gallatin River lot included 53 specimens less than three months old (6.8–26 mm. total length) and 768 more than three months old (21–118 mm.). The Prickley Pear Creek specimens ranged in total length from 42 to 118 mm.

All lengths and weights were taken after specimens were preserved (10 percent formalin) except for 36 fish which were measured while fresh. The length measurements on fresh specimens were converted to preserved lengths by the factor 0.960. Sex and maturity were determined whenever possible by careful examination without making micro-sections of the gonads.

Stomachs were removed by slitting the sculpins from anus to throat, cutting the esophagus at the posterior end of the oral cavity and breaking off the intestine at the pyloric valve which forms a convenient and definite posterior demarcation between stomach and intestine. Stomachs were then placed in 70 percent ethyl alcohol before the contents were removed and classified. Food organisms were generally determined to family, but some specific identifications were made. Insect fragments were recorded as unidentifiable insects.

Table I

List of Foods Found in Sculpin Stomachs From the West Gallatin River

- Mollusca
  - *Physa*
  - *Pisidium*
- Insecta
  - Ephemeroptera (nymphs)
    - Heptageniidae
      - *Heptagenia*
      - *Rhithrogena*
    - Baetidae
      - *Paraleptophlebia bicornuta*
      - *Ephemerella doddsi*
      - *Ephemerella flavilinea*
      - *Baetis*
  - Plecoptera (nymphs)
    - Pteronarcidae
      - *Pteronarcys californica*
      - *Pteronarcella badia*
    - Taeniopterygidae
    - Nemouridae
    - Capniidae
    - Perlidae
      - *Classenia sabulosa*
    - Perlodidae
      - *Arcynopteryx parallela*
    - Chloroperlidae
    - Isoperlidae
      - *Isoperla*
  - Coleoptera (larvae and adults)
    - Carabidae
    - Haliplidae
    - Dryopidae
      - *Helmis*
  - Hemiptera
  - Trichoptera (larvae and pupae)
    - Rhyacophilidae
      - *Rhyacophila*
      - *Glossosoma*
    - Hydropsychidae
      - *Arctopsyche*
      - *Hydropsyche*
    - Hydroptilidae
    - Limnephilidae
    - Lepidostomatidae
    - Brachycentridae
      - *Brachycentrus*
    - Helicopsychidae
  - Diptera (larvae and pupae)
    - Tipulidae
      - *Tipula*
      - *Antocha*
    - Tendipedidae (Chironomidae)
    - Ceratopogonidae
    - Blepharoceridae
      - *Bibiocephala*
    - Simuliidae
- Arachnida
  - Hydrachnidae
- Fish
  - *Rhinichthys cataractae*
  - *Cottus bairdi*
- Fish eggs
  - *Cottus bairdi*

Due to the small amounts of food present, it was not practical to measure volumes of individual stomachs. In order to obtain the volumetric measurement of food eaten, total volumes were determined by alcohol displacement of the stomach contents of 17 separate collections. The average volume of food per

stomach was 0.09 ml. and the maximum volume was 2.30 ml.

Composition of Food.—Food studies on *Cottus bairdi* by Ricker (1934), Koster (1936), and Dineen (1951) indicate that this species feeds mainly on bottom dwelling aquatic fauna and is not a serious predator of game fish species. The present study agrees with these findings (Table I). Bottom dwelling aquatic insects made up 99.7 percent of the total number of all food items in the stomachs of the older sculpins from the West Gallatin River. Items such as snails (*Physa*), fingernail clams (*Pisidium*), water mites (Hydrachnidae), sculpin eggs, and fish composed the other 0.3

TABLE II

STOMACH CONTENTS OF 15 WEST GALLATIN RIVER SCULPINS (TOTAL LENGTHS 14–26 MM.) COLLECTED AUGUST 31, 1951

Food organism	Number of fish with organism	Average number per stomach	Percentage of total number of organisms
Mollusca (*Pisidium*)	5	1.4	3.8
Ephemeroptera			
Baetidae	2	1.0	1.1
Paraleptophlebia	1	1.0	0.5
Heptageniidae			
Heptagenia	1	1.0	0.5
Plecoptera	1	1.0	0.5
Diptera larvae	1	1.0	0.5
Chironomid larvae	14	12.4	92.6
Unidentified insects	1	1.0	0.5

percent. The only terrestrial insect taken was an adult ground beetle.

Dipterous larvae and pupae, the most abundant food items, comprised 55.5 percent of the total and occurred in 60.3 percent of the stomachs. The Tendipedidae (Chironomidae) was the most important family. Chironomid larvae and pupae accounted for 95.6 percent of the Diptera. Larvae made up 99.6 percent of the Tendipedidae while pupae constituted only 0.6 percent. Chironomid larvae were also the most abundant Diptera in the stomachs examined by Ricker (1934), Koster (1936), and Dineen (1951). Caddis fly larvae, second only to the Diptera in numbers consumed, accounted for 36.7 percent of all food items and occurred in 58.3 percent of the stomachs. Lepidostomatidae and Hydropsychidae were the most important families, constituting 69.8 and 24.4 percent, respectively. Mayfly nymphs made up only 3.8 percent of the total number of food items but occurred in 32.8 percent of the stomachs. Plecoptera nymphs, with 2.1 percent of the total number of food items, occurred in 16.8 percent of the stomachs. Despite the fact that mayfly and stonefly nymphs comprised a low percentage of the total number, they were an important food because of their large size and rather regular occurrence. Fish and fish eggs comprised 0.1 percent of the food items eaten and occurred in 0.8 percent of the stomachs. Snails, fingernail clams, beetles, true bugs, and water mites collectively constituted only 0.2 percent of the total number of food organisms and occurred in only 2.6 percent of the stomachs. Unidentifiable insects made up the remaining 1.6 percent of the food items. Sticks and stones which were presumed not to be parts of caddis fly cases were found in 5.2 percent of the stomachs.

The smallest sculpins which had food in their stomachs were collected July 21, 1951, from the West Gallatin River. Only three specimens (total lengths 9.1–10.0 mm.), of a sample of 15 ranging in total length from 6.8 to 10.4 mm., contained food. Unabsorbed yolk sacs were still present in 12 of the fry. The only identifiable food items were a chironomid larvae and one water mite. The yolk sacs were completely absorbed in 23 sculpins (total lengths 9.1–14.8 mm.) taken July 31, 1951. All had been feeding on chironomid larvae and, in addition, two specimens had one mayfly nymph each, another had a fingernail clam, and a fourth had an unidentifiable insect larvae. Chironomid larvae accounted for 128 (97.7 percent) of the total number of food organisms.

Stomach examinations were made on 15 young of the year (total lengths 14–26 mm.) collected on August 31, 1951 (Table II). Chironomid larvae occurred in all but one and comprised 92.6 percent of the total number of food organisms. Fingernail clams accounted for 3.8 percent of the total. Other items included mayfly and stonefly nymphs. These findings are generally in agreement with those of Ricker (1934).

Larger sculpins were divided into three size groups (total lengths 21–50 mm., 51–80 mm., and 81–118 mm.) in order to facilitate comparison of food habits (Table III). In the West Gallatin River, mollusks occurred in the stomachs of all three size groups. Fingernail clams were taken by the smallest size group and snails by the two larger groups. In Prickley Pear Creek, however, the larger sculpins took both fingernail clams and snails.

Stonefly nymphs were consumed in greatest numbers by the largest size group and least by the smallest. The smallest size group utilized only small nymphs of the families Capniidae, Perlodidae, Chloroperlidae, and Isoperlidae while the two largest size groups contained, in addition, nymphs of the families Pteronarcidae, Taeniopterygidae, Nemouridae, and Perlidae. Caddis fly larvae were consistently more abundant in the stomachs of the larger sculpins. Diptera larvae and pupae were taken in greatest numbers by the larger specimens but made up a higher percentage of the total number of food organisms eaten by the smaller fish. Chironomid larvae were the most common Diptera found in all sizes of sculpins. However, cranefly larvae (*Tipula*) occasionally contributed more to the total volume due to their large size.

Fish and fish eggs were not important items in the diet of West Gallatin River sculpins. Only five specimens had fish in their stomachs; the smallest one was a female with a total length of 80 mm. Four males (86–111 mm.) each contained one fish. Only two of the fish eaten were identified; one was a longnose dace (*Rhinichthys cataractae* Valenciennes) and the other a yearling sculpin. One male (105 mm.), taken June 30, 1951, had seven fungused sculpin eggs in its stomach. Eyed sculpin eggs were found in the stomachs of two adult males taken June 28, 1950, from Prickley Pear Creek.

TABLE III

FOOD IN RELATION TO SIZE OF 768 SCULPINS FROM THE WEST GALLATIN RIVER 1950–1951

Food organism	222 stomachs, total lengths 21–50 mm				324 stomachs, total lengths 51–80 mm.				222 stomachs, total lengths 81–118 mm.			
	Greatest number in any fish	Average number of organisms in stomachs containing them	Percent of fish with organism	Percent of total number of all foods taken	Greatest number in any fish	Average number of organisms in stomachs containing them	Percent of fish with organism	Percent of total number of all foods taken	Greatest number in any fish	Average number of organisms in stomachs containing them	Percent of fish with organism	Percent of total number of all foods taken
Mollusca	1	1.0	0	0	3	1.3	2	0	3	1.7	0	0
Ephemeroptera	4	1.3	33	7	10	1.8	33	4	12	2.0	32	3
Plecoptera	6	1.2	10	2	7	1.5	15	2	29	2.4	26	3
Coleoptera	1	1.0	0	0	...	...	...	...	1	1.0	3	0
Hemiptera	...	...	...	...	...	...	...	...	1	1.0	0	0
Trichoptera	7	2.3	36	13	57	6.9	64	31	194	15.9	72	47
Diptera	57	8.0	58	74	149	13.5	63	61	290	19.2	58	46
Unidentifiable insects	1	1.0	22	4	5	1.2	19	2	2	1.1	22	1
Arachnida	...	...	...	...	5	5.0	0	0	...	...	...	...
Fish	...	...	...	...	1	1.0	0	0	1	1.0	2	0
Fish eggs	...	...	...	...	...	...	...	...	7	7.0	0	0

Of 17 Prickley Pear Creek sculpins (98–118 mm.) collected September 21, 1950, three were found to contain fish; two of the items were rainbow trout (*Salmo gairdneri* Richardson) approximately 2½ inches long. These trout may have been from fingerlings (2–5 inches total length) planted on September 18, 1950.

Predation by freshwater sculpins on game and commercial fishes has been investigated by several fishery workers. Forbes (1883)

reported that 25 percent of the food of six *Cottus bairdi* was fish. Lincoln (1933) stated that muddlers had been observed to take recently planted trout 1½–2 inches long. Dineen

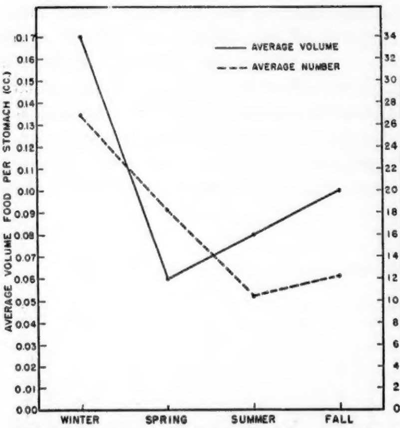


Fig. 1. Amount of food in sculpin stomachs at various seasons from the West Gallatin River.

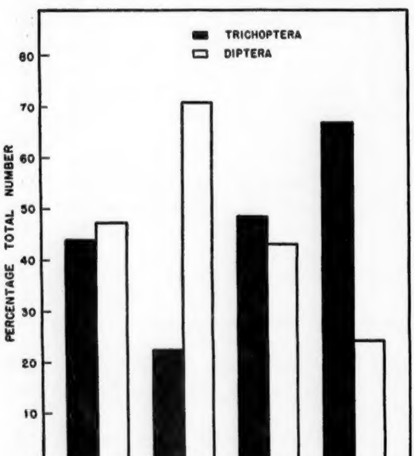


Fig. 2. Number of Trichoptera and Diptera at various seasons in stomachs of sculpins from the West Gallatin River.

(1951) examined the stomachs of over one thousand *Cottus bairdi bairdi* and found 4.0 percent contained a few trout eggs. Simon and Brown (1943) reported a small male (*Cottus bairdi semiscaber*) gorged with sculpin eggs and fry. Dence (1928), Greeley (1932), Ricker (1934), and Surber (1920) reported no evidence that *Cottus bairdi* eats fish or fish eggs. Koster (1936) concluded that sculpins do not destroy large numbers of trout eggs or fry. This species apparently is not a serious predator of game fish although it may take trout under certain conditions and occasionally eats small individuals of its own kind.

Seasonal Variations.—The volume and number of food items per stomach in sculpins from the West Gallatin River were compared for the various seasons of the year (Fig. 1). The calendar year was divided into four periods of equal length. On the basis of water temperatures, December through February was designated as the winter season. There were fewer empty stomachs and the quantity of food per stomach was greatest in the winter samples. The percentage of empty stomachs ranged from 4.0 percent in winter to 10.3 percent in summer and the average volume of food per stomach ranged from 0.06 ml. in spring to 0.17 ml. in winter. An examination of 62 specimens collected when water temperatures were very low (32–33°F.) showed the average volume per stomach to be 0.25 ml. while the winter average was 0.17 ml. Only one stomach was empty and the average number of food items per stomach was 31.6, which is higher than the winter average of 25.9.

There were obvious variations in the kinds of food consumed. Snails were found only in the summer and fall collections. The number of stomachs containing stonefly nymphs was more than five times greater during the winter than in summer. Caddis fly larvae occurred in greatest numbers in fall collections and least in spring, while Diptera were taken more often in spring and least in fall (Fig. 2). Tipulidae larvae were consumed during all seasons but were most important in the stomachs of large sculpins collected in the fall.

Habitat and Movements

Sculpins were abundant in riffle areas where rubble and boulders were predominant, and were usually absent from pools where the bottom was entirely sand or clay. They were numerous in the dense mats of white water-crowfoot in Prickley Pear Creek. Some small sculpins were observed to hide in the quiet

water near shore by stirring up clouds of sitl which settled and covered them. Larger individuals were found most commonly in rubble riffle areas where the water was more than 4 inches deep but some were present in the shallow quiet water near shore. Distribution was not noticeably affected by surface velocities because sculpins spend much of their time under gravel and rubble on the stream bottom. However, sculpins were scarce in areas where currents were slow enough to allow deposits of sand and silt, probably due to the absence of hiding places.

A total of 75 sculpins (total lengths 50–140 mm.), captured in Prickley Pear Creek with the assistance of an AC electric shocker, were marked with serially numbered jaw tags and released in the same 600-foot section from which

TABLE IV

RECOVERIES OF TAGGED SCULPINS IN PRICKLEY PEAR CREEK

Date	Number tagged	Number recovered	Number of days between shockings
June 30, 1950	36	..	..
August 15, 1950	39	9	46
September 25, 1950	..	6	41
November 24, 1950	..	3	60
June 17, 1951	..	3	205
Totals	75	21	352

they were captured. In four successive shockings, 21 marked specimens (total lengths 70–140 mm.) were recovered (Table IV). Only one marked fish was captured more than once. This specimen was tagged June 30, 1950, and recaptured on August 15 and again on September 25 of the same year. Fifteen (71.4 percent) of the 21 sculpins recovered were within 150 feet of the point where first captured. The greatest distance which a recovered sculpin had moved from the point of release was 470 feet.

SPAWNING HABITS

Spawning Season.—The 1950 spawning season was not definitely established, but eyed eggs were collected in the West Gallatin River on June 17 and in Prickley Pear Creek on June 15. The 1951 spawning season in the West Gallatin River covered most of the month of June. On June 5, 1951, one spent female was found in a sample of 147 gravid females. The first two nests with eggs were found on June 9. One nest had 104 eggs and the other 148. First eyed eggs of the 1951 season were found on June 23. All eggs were eyed in the 14 nests located on July 6. The last females (four specimens) to contain numerous eggs were found on June 23. One collected June 30, 1951, had eight eggs.

Ricker (1934) gave the middle of May as the spawning period. Hann (1927) and Gage (1878) observed eggs in April, and Smith (1922) found them in April and May. Simon and Brown (1943) reported the spawning season of *Cottus bairdi semiscaber* Cope as February 20 to May 26.

Males were ripe in advance of the females and some were still capable of producing milt after all females had deposited their eggs. Milt was obtained from males as early as March 25 in the 1950 season. In 1951, the first ripe males were found on April 25. Females were also slower to begin ripening in 1951 than in 1950. The last ripe male of the 1951 season was found on August 31. Afternoon water temperatures during the 1951 spawning season ranged from 46° to 55°F. Hann (1927) observed sculpins spawning in an aquarium at a temperature of 55°F. and reported stream temperatures of 41° to 61°F. during the spawning season.

Age and Size at First Spawning.—Hann (1927) stated that sexual maturity was attained at two years of age when sculpins were 45–70 mm. standard length and that males were larger than females. In a sample of 390 females collected from the West Gallatin River during the period from May 27 to June 10, 1951, all individuals over 74 mm. total length were sexually mature (Table V). The smallest one which was sexually mature had a total length of 57 mm. Of 25 females collected during May and June, 7 were sexually immature and 2 years old, 9 were mature and of the same age, and 9 were mature and 3–5 years of age. Maturity of males was not easily determined from the appearance of the testes. The smallest male which produced milt by application of pressure to the abdomen had a total length of 70 mm. and was 2 years old.

Sexual Characteristics.—Mature females in the gravid condition are easily recognized by their distended abdomens. Adult males have a prominent genital papilla (Hann 1927) which originates at the posterior margin of the anus. The genital papilla can be seen without magnification on most preserved males as small as 60 mm. total length. The sex of 177 preserved sculpins (total lengths 57–113 mm.) was determined first by inspection for the presence or absence of the genital papilla and then verified by examination of the gonads. Sex was correctly determined by the use of the papilla in 96 percent of the specimens. This sample contained 89 males and 88 females. Hann (1927) stated that sex may be determined

TABLE V

NUMBER AND PERCENTAGE OF MATURE FEMALE SCULPINS FROM THE WEST GALLATIN RIVER

Total length (in mm.)	Total fish observed	Number mature	Percentage mature
50–54	44	0	0.0
55–59	101	1	1.0
60–64	72	12	16.7
65–69	38	21	55.3
70–74	46	42	91.3
75–79	43	43	100.0
80–84	24	24	100.0
85–89	15	15	100.0
90–94	4	4	100.0
95–99	2	2	100.0
100–104	1	1	100.0

by the shape of the head in specimens three or more years of age—that of the male is broader. A comparison was made between the greatest head widths of 30 males and 15 females ranging in total length from 82 to 95 mm.; the average width for the males was 23.9 mm. and for the females was 21.9. The accuracy of this method of determining sex was about 80 percent. Simon and Brown (1943) stated that in *Cottus bairdi semiscaber* the differences in coloration of the first dorsal fin could be used to separate the sexes. This characteristic was not diagnostic for *Cottus bairdi punctulatus*.

Development of Ovaries.—Ovaries were obtained from 146 specimens collected at frequent intervals between January 21 and May 31, 1950, and December 26, 1950, to June 5, 1951. No samples were taken after fish began to spawn. Ovary volumes after preservation were determined to the nearest 0.01 ml. by alcohol displacement. The object of this study was to determine the stages of ripeness. Volumes of the ripening ovaries were influenced by the size of the female as well as by the state of ripeness. Ovary volumes had an approximate straight-line relationship to the cube of the total body length. Ripeness factors were calculated by dividing the ovary volumes by the cubes of the total body lengths. The resulting factors were arbitrarily multiplied by 10^8 to obtain more convenient figures. Average ripeness factors for each of the small samples

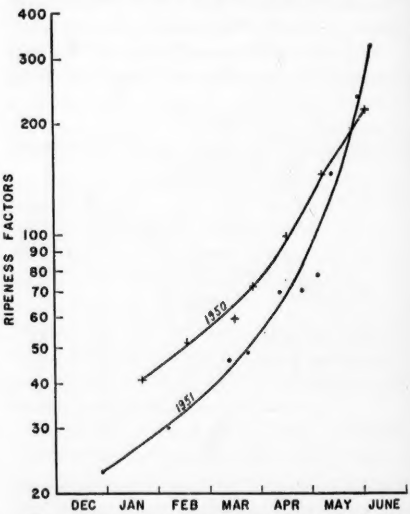
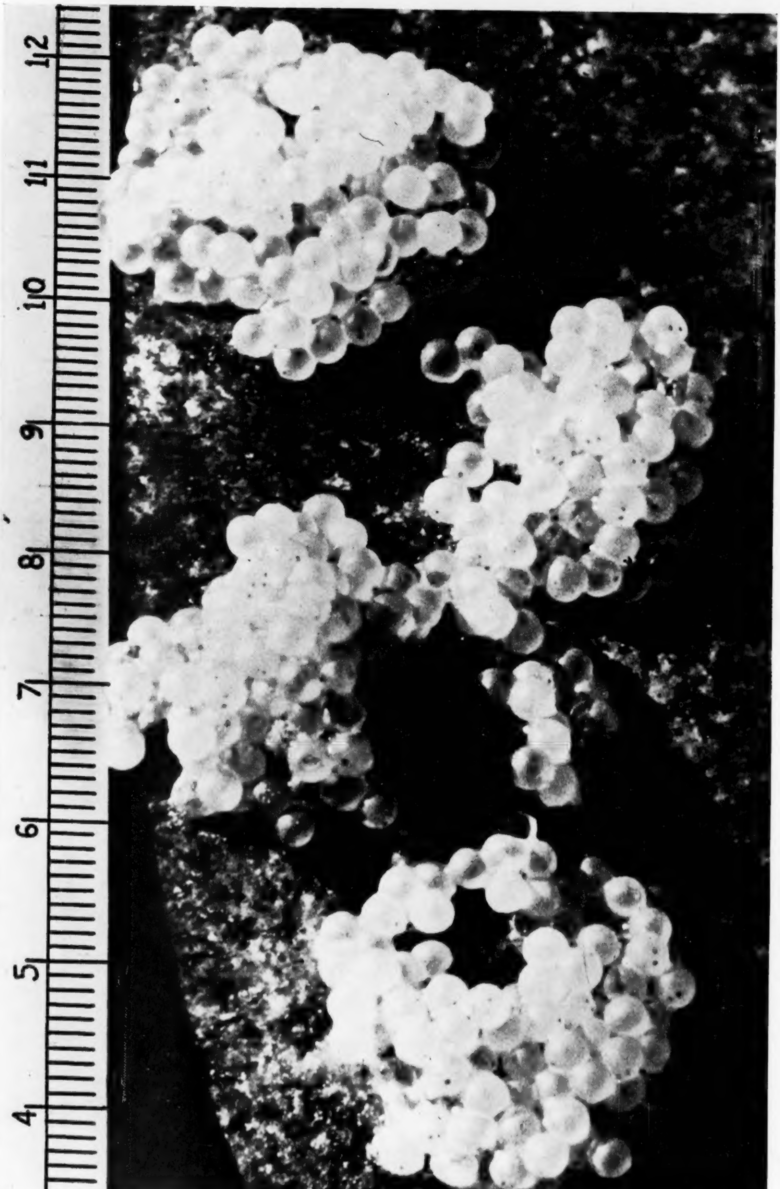


Fig. 3. Average ripeness factors for 146 female sculpins.

were plotted on semilog graph paper. The resulting curves were drawn by inspection (Fig. 3). The average ripeness factor for the 1950 collections increased from 40.4 (January 21) to 209.7 (May 31). In the following year the factor increased from 22.8 (December 26, 1950) to 329.0 (June 5, 1951). The 1950 curve is not complete as no ovaries were measured in the period immediately before spawning.

Number of Eggs.—Egg counts were made on 118 preserved females (57–95 mm. total length). The average number of eggs per female was 203. The minimum was 69 in a 57-mm. specimen and the maximum was 406 in a 94-mm. fish. Hann (1927) counted the eggs from nine females



Sculpin eggs attached to under surface of rock. Scale graduated in mm. Photo by R. Hays.

which were 51 to 71 mm. standard length. These ranged from 120 to 395 eggs per female (average 257). Simon and Brown (1943) found an average of 629 eggs per female in *Cottus b. semiscaber*.

Preparation and Distribution of Nests.—The nests consisted of holes under rocks or other suitable objects. Preparation of nests was not observed but was presumed to have been done by the males (Hann 1927). There was a greater abundance of adult males in the deeper areas where the first nests were found. Adult females were most abundant in shallow water near shore at that time. In a sample of 12 specimens taken May 27, 1951, from water less than 18 inches deep, the ratio of males to females was 1:5. On June 5 a collection of 30 specimens from the same area showed a ratio of 1:9. In water more than 18 inches deep, 22 adults collected June 5 showed a ratio of 1:0.7. On June 10 females were caught near shore in shallow water, while males were found only in deep water. This segregation of sexes was not noticeable during any other season of the year. The first eggs deposited were found in water over one foot deep.

The rocks under which nests were prepared varied in diameter from about 5 to 15 inches. Egg clusters were sometimes attached to materials other than rocks. Hann (1927) reported the use of aquatic vegetation, C. J. D. Brown found clusters on a piece of submerged wood in the Madison River, Montana, and the writer observed eggs on a rusty piece of sheet iron in Prickley Pear Creek.

Surface velocities over nests varied from 0.0 to 4.6 feet per second. Simon and Brown (1943) found nests in areas where currents varied from rapid to almost none. Most nests were originally located in areas where surface velocities were high but which became much reduced as water levels dropped. Observations indicated rather gentle water movements within the nests but limitations of available equipment prevented accurate determinations.

Description of Eggs and Egg Clusters.—The size of eggs was determined from preserved materials. Such measurements, although they may not give a true picture of size, are useful in comparing egg diameters of different individuals and at different times. Diameters were secured by counting the eggs which would lie side by side on a millimeter linear scale. Eggs from 48 females collected from the West Gallatin River in 1951 varied from 1.3 mm. in diameter in April to 2.2 mm. by June 5. Eggs collected from 11 nests had diameters of 2.5 to 2.9 mm. Simon and Brown (1943) found that eggs from females ready to spawn had a diameter of 2.2 mm. and eggs from nests averaged 2.47 mm. in diameter.

Egg colors ranged from pale yellow to orange-yellow. However, all eggs from a single individual were the same color (Hann 1927). The eggs became progressively darker as the embryos developed. The larger egg clusters were usually composed of small component clusters (Plate I) in which the eggs often differed in size, color, and stage of development (Smith 1922).

The number of eggs from twelve nests, collected June 21–July 5, 1951, from the West Gallatin River, ranged from 54 to 1587 eggs per nest with an average of 744. Since the largest number of eggs found in any female was 406, it is obvious that many nests were used by more than one female. In Prickley Pear Creek, the largest number of eggs found in any female was 437 and the maximum number in any nest was 1884.

Incubation Period and Care of Nests.—On the basis of 1951 spawning dates (June 5–30) and hatching dates (July 3–21), the incubation period in the West Gallatin River was 21–28 days. Afternoon water temperatures during this period ranged from 46 to 63°F. Eggs taken artificially and fertilized with sperm from macerated testes were placed on hatching trays in water at a temperature of 48–50°F. Hatching began 30 days after fertilization but was not complete until 10 days later. These eggs became heavily fungused and were given frequent treatments with copper sulfate. Hann (1927) found that eggs, taken artificially, hatched in twenty days at temperatures of 55 to 59°F.

An adult sculpin was present in almost every nest found. Sculpins captured from 11 nests in Wolf Creek and 5 nests in the West Gallatin River were all males. Smith (1922) observed that almost all nests had guardians and caught four which were males. Hann (1927) stated that the male guards the nest while the eggs are incubating. On the basis of observations made to date, however, the writer does not believe that males actually guard the nests,

Sculpin eggs attached to under surface of rock. Scale graduated in mm. Photo by R. Hays.

and prefers to refer to them as attendants rather than guardians. Simon and Brown (1943) observed that the nests were rarely unaccompanied by the male fish. Females were found in nests only during the spawning season and were usually accompanied by the male. Three West Gallatin River nests were visited twice weekly during the incubation period. The attendant parents were not observed on every occasion but it was evident that attendance was continued until hatching was nearly complete. Attendant males apparently served to keep the nests clean. Nests were remarkably free of silt, debris, and aquatic organisms which could otherwise be expected to accumulate. Very few fungused eggs were found in the nests. The presence of seven fungused eggs in the stomach of an attendant male might indicate that such eggs are sorted from the clusters.

TABLE VI

TOTAL LENGTHS OF HATCHERY-INCUBATED SCULPIN FRY

Age (days)	Total lengths (in mm.)			Number of specimens
	Minimum	Maximum	Average	
1	5.8	8.1	7.1	43
2	6.9	8.0	7.6	3
4	8.4	9.1	8.7	3
7	7.7	9.5	8.8	3
9	8.8	9.0	8.9	3
14	9.0	9.9	9.5	3

No eggs were observed to be left above the receding water level in Prickley Pear Creek, but 14 West Gallatin River nests were found stranded above the water level in 1951. Hann (1927) found no nests left above changing water levels and Gage (1878) felt that the fish had forethought as the eggs were never laid above the low water mark of July.

AGE AND GROWTH

Sac Fry.—All sculpins used in the aging studies were from the West Gallatin River. Egg clusters were incubated in hatchery troughs. Fry were held at temperatures of 51–56°F., until their yolk sacs were completely absorbed. Total length measurements of fry were made on preserved specimens. Fry ranged from 5.8 to 8.1 mm. and averaged 7.1 mm. on their first day of life (Table VI). Hann (1927) reported the standard length to be about 6.4 mm. at the time of hatching, and Simon and Brown (1943) found the average total length of artificially hatched fry was 6.9 mm. On the 14th day the yolk sacs were completely absorbed and total lengths ranged from 9.0 to 9.9 mm. with an average of 9.5 mm. After the yolk sac was absorbed, young sculpins closely resembled their parents except for size.

Young Sculpins.—Juvenile sculpins up to about 14 months of age could usually be distinguished from other age classes on the basis of size. Average total lengths of preserved young sculpins increased from 7.8 mm. on July 16, 1951, to 19.5 mm. on August 31. The average total length of 110 specimens collected in October, 1950, was 31.4 mm. (Table VII) and the average total length of 54 yearlings collected in May, 1951, was 32.5 mm. This would indicate very slow growth during the winter months. From June to the end of August, the average total lengths increased from 35.9 mm. (245 specimens) to 52.9 mm. (7 specimens).

TABLE VII

TOTAL LENGTHS OF JUVENILE SCULPINS COLLECTED FROM WEST GALLATIN RIVER

Month of collection	Number of specimens	Total lengths (in mm.)		
		Minimum	Maximum	Average
October........	110	23	41	31.4
December......	55	23	41	29.0
February.......	14	22	34	29.4
March.........	14	21	34	28.4
April..........	17	27	39	30.9
May...........	54	25	41	32.5
June...........	245	26	51	35.9
July...........	13	38	53	45.5
August........	7	48	60	52.9

Older Sculpins.—Otoliths were taken from 151 fresh specimens. These were stored in 95 percent ethyl alcohol and then examined by the use of reflected light (magnifications 9×-36×) while immersed in oil of cloves. Narrow translucent rings alternating with wider opaque zones were visible. The white opaque zones were presumed to represent summer growth while the translucent rings evidently represent winter marks or annuli. The core of each otolith

was generally opaque white surrounded by a somewhat translucent band. The area immediately outside the core was an opaque zone representing the first summer's growth.

Ages were determined from the otoliths of specimens collected a few at a time from February 25, 1950, to August 5, 1951. Total length measurements were made on fresh fish before the removal of otoliths. The smallest sculpins from which otoliths were taken (22–34 mm.) were collected February 6, 1951. These had only one annulus and this was on the outer edge of the otoliths (Table VIII). The largest specimen from which otoliths were taken, was a 119 mm. male collected November 11, 1950; it had four annuli. Three specimens had five annuli; two were females (93 and 94 mm.), and one was a male (110 mm.). Average total lengths in mm. for the five age groups ranged as follows: I—29.6–56.7; II—64.4–79.3; III—80.5–98.0; IV—84.0–118.5; and V—93.0–110.0.

Sex was determined for 112 specimens and average total lengths of males and females were compared in each age class (Table IX). The males were consistently larger than the females (Hann, 1927, and Simon and Brown, 1943).

TABLE VIII

AVERAGE TOTAL LENGTHS OF EACH AGE GROUP OF SCULPINS COLLECTED IN WEST GALLATIN RIVER
(Lengths in mm., number of specimens in parentheses)

Number of annuli	Feb.	March	May	June	July	August	Sept.	Nov.
I	29.6 (14)	31.0 (1)	31.7 (16)	33.3 (6)	40.7 (3)	51.5 (6)	56.7 (3)	...
II	69.2 (6)	67.6 (5)	64.4 (11)	67.5 (17)	70.2 (4)	...	79.3 (3)	...
III	80.5 (8)	81.2 (8)	83.0 (3)	80.9 (7)	87.5 (2)	...	98.0 (1)	...
IV	102.2 (4)	98.7 (9)	96.9 (8)	84.0 (1)	...	...	...	118.5 (2)
V	94.0 (1)	...	...	93.0 (1)	...	...	...	110.0 (1)

TABLE IX

NUMBER AND AVERAGE TOTAL LENGTHS OF MALES AND FEMALES IN EACH AGE GROUP

Number of annuli	Males		Females	
	Number	Average total length (in mm.)	Number	Average total length (in mm.)
I	5	57.0	2	48.5
II	20	70.7	29	66.1
III	10	83.1	19	81.6
IV	17	103.7	7	90.0
V	1	110.0	2	93.5

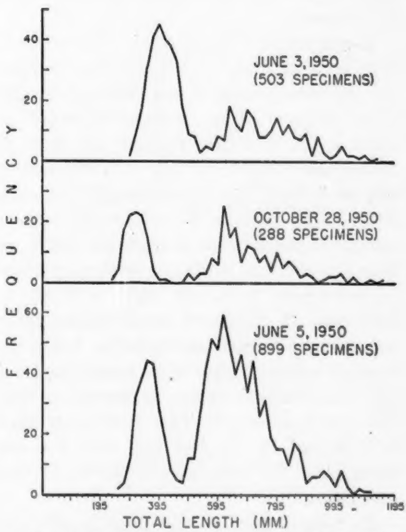


Fig. 4. Length-frequency curves for three collections of sculpins from the West Gallatin River.

Length-frequency Distribution.—A length-frequency study was made on 1681 specimens collected on the following dates: 503, June 3, 1950; 288, October 28, 1950; 899, June 5, 1951. A length interval of 2 mm. was used in preparing the frequency polygon (Fig. 4). Age

group I showed a mode at 39.5 mm. in the June 3 collection and at 61.5 in the October sample. The mode at 31.5 mm. in the October polygon represents sculpins hatched during the summer of 1950. The peak of the first mode in the June 5, 1951, collection was at 35.5 mm.

Fish two years old and older did not show clearly defined modes in any of the collections. However, a comparison of the June 3, 1950, length-frequency polygon with the mean total lengths of June specimens aged by otoliths (Table VIII) indicated satisfactory agreement between the two methods.

The largest sculpins obtained for this study were collected by William D. Clothier in irrigation canals which originate in the West Gallatin River. One male had a total length of 140 mm. after preservation and a female measured 124 mm. The largest sculpin found in Prickley Pear Creek was a male 139 mm. in total length. The largest sculpin reported by Hann (1927) was a male with a standard length of 113 mm.

Length-weight Relationship.—The relationship between fresh total lengths and weights for the sexes combined was obtained for 206 West Gallatin River sculpins collected as follows: 179 specimens October 28, 1950; 3, November 9, 1950; 19, July 3, 1951; and 7, August 5, 1951. The weight-length data were fitted to the equation $W = CL^n$ where W = weight in grams, C = a constant, and L = length in mm. The resulting equation expressed in logarithmic form was $\log W = \bar{5}.202 + 3.16(\log L)$. A calculated length-weight curve was prepared which satisfactorily fitted the average length-weight values computed for 5 mm. class intervals except for specimens over 109 mm. total length. This discrepancy may be explained by the fact that only five fish larger than 109 mm. were available for the calculations.

The relationship between total lengths and standard lengths of preserved sculpins was determined for 147 specimens (total lengths 10–124 mm.) selected to give nearly equal representation to all sizes. The equation representing the least-squares line of relationship was $Y = -1.032 + 0.827X$ where Y = standard length in mm. and X = total length in mm.

Summary

An investigation was made on the life history and ecology of the Rocky Mountain mottled sculpin, *Cottus bairdi punctulatus*, in the West Gallatin River, Prickley Pear Creek, and Wolf Creek, Montana. The study began in January 1950 and continued until October 1951. An analysis of 903 sculpin stomachs showed that bottom-dwelling aquatic insects comprised 99.7 percent of the total number of food organisms consumed; of these, Diptera larvae and pupae constituted 55.5 percent; caddis fly larvae and pupae, 36.7 percent; mayfly nymphs 3.8 percent; stonefly nymphs, 2.1 percent; unidentifiable insects, 1.6 percent; fish and fish eggs, 0.1 percent; and all others, 0.2 percent. Caddis flies were consumed in greatest numbers during fall and least in spring while Diptera were taken most in spring and least in fall.

The maximum amount of food per stomach occurred during the winter months (temperatures 32–33°F.), while the minimum was found in the summer. Almost all samples for food analysis were collected in the afternoon.

Sculpins were most abundant in riffle areas, where rubble and boulders predominated, and were least abundant where the bottom was entirely sand or clay. The young typically inhabited quiet waters.

Twenty-one marked sculpins from a total of 75 released in Prickley Pear Creek were recaptured within 470 feet of the point of release.

The 1951 spawning season was from June 5 to 30 and hatching occurred from July 3 to 21, indicating an incubation period of 21 to 28 days. Afternoon water temperatures during this period ranged from 46 to 63°F. Sexual maturity was attained by some individuals at the age of two years. All females over 74 mm. total length were sexually mature.

An attempt was made to determine sex by such external characters as the distended abdomens of females, the genital papillae of males, and head widths, and these methods of sex determination were verified by examination of the gonads.

Development of ovaries was determined by calculating ripeness factors based on the ovary volume and the cube of the total length of the fish. The number of eggs per female averaged

203 and ranged from 69 to 406. The number of eggs per nest ranged from 54 to 1587 and averaged 744, indicating that many nests were used by more than one female.

The nests, which were merely holes under rocks or other suitable materials, were prepared and attended by the males.

Total lengths of fry one day old or less ranged from 5.8 to 8.1 mm. and yolk sacs were completely absorbed after two weeks when lengths ranged from 9.0 to 9.9 mm. Average total lengths of young sculpins increased from 7.8 mm. in July to 31.4 mm. in October. The same age group averaged 32.6 mm. in the following May, and 52.9 mm. in August.

As a result of otolith studies on 151 specimens, average total lengths of five age groups were as follows: age group I, 29.6–56.7 mm.; II, 64.4–79.3 mm.; III, 80.5–98.0 mm.; IV, 84.0–118.5 mm.; and V, 93.0–110.0 mm.

Length-frequency data in general agreed with growth data based on otolith studies. The length-weight relationship for 206 sculpins was expressed by the equation $\log W = \bar{5}.202 + 3.16(\log L)$. The equation $Y = -1.032 + 0.827X$ represents the relationship between total length (X) and standard length (Y) of 147 preserved specimens.

Literature Cited

Dence, Wilford A. 1928. A preliminary report on the trout streams of southwestern Cattaraugus Co., N. Y. *Roosevelt Wild Life Bull., 5 (1): 145–210.*

Dineen, Clarence F. 1951. A comparative study of the food habits of *Cottus bairdii* and associated species of Salmonidae. *Amer. Midl. Nat., 46 (3): 640–45.*

Forbes, S. A. 1883. The food of the smaller fresh-water fishes. *Bull. Ill. State Lab. Nat. Hist., 1 (6): 65–94.*

Gage, Simon H. 1878. Notes on the Cayuga Lake star gazer. *The Cornell Review, 6 (2): 91–94.*

Greeley, John R. 1932. The spawning habits of brook, brown, and rainbow trout, and the problem of egg predators. *Trans. Amer. Fish. Soc., 62: 239–48.*

Hann, Harry W. 1927. The history of the germ cells of *Cottus bairdii* Girard. *Jour. Morph. and Physiol., 43 (2): 427–97.*

Koster, William J. 1937. The food of sculpins (Cottidae) in central New York. *Trans. Amer. Fish Soc., 66: 374–82.*

Lincoln, Guy. 1933. *Trans. Amer. Fish. Soc., 63rd Ann. Meeting, pp. 62–63* (Under discussion of paper by C. L. Hubbs).

Needham, James G., and Paul R. Needham. 1941. A guide to the study of fresh-water biology. 4th ed. *Comstock Publ. Co., Inc., Ithaca, N. Y., 88 pp.*

Ricker, William E. 1934. An ecological classification of certain Ontario streams. Univ. of Toronto Studies, Biol. Ser. No. 37, *Publ. Ont. Fish. Res. Lab., No. 49: 1–114, figs. 1–11.*

Simon, James R., and Robert C. Brown. 1943. Observations on the spawning of the sculpin, *Cottus semiscaber*. Copeia (2) 41–42.

Smith, Bertram G. 1922. Notes on the nesting habits of *Cottus*. *Pap. Mich. Acad. Sci., Arts and Letters, 2: 221–25.*

Surber, Thaddeus. 1920. Fish and fish-like vertebrates of Minnesota. *Bien. Rep. Minn. State Game and Fish Comm. for 1920, 1–92.*

910 Grand Avenue, Missoula, Montana.

The Vertebral Axis of Two Species of Centrarchid Fishes

Paul S. Stokely

OTHER than the generalized description of the skeleton of the yellow perch commonly encountered in text books, there is a notable paucity of specific literature regarding the osteology of freshwater fishes. Yet studies of vertebral variation alone among marine teleosts lead Ford (1937) to say, "Almost every aspect of vertebral variation discussed is a worthy subject for intensive study, likely to yield highly interesting and useful results." It seemed that a similar study of freshwater forms ought to prove equally fruitful. It was in this frame of mind that the present investigation was undertaken.

The writer is especially indebted to the following teaching fellows in the Department of Biology of the University of Notre Dame: Mr. Robert Shaver for his painstaking drawings, and Messrs. Joseph Berberian and Lawrence Monaco for their assistance in the collection and preparation of the specimens.

The data on the bluegill sunfish, *Lepomis m.*

macrochirus Rafinesque, and the warmouth, *Chaenobryttus coronarius* (Bartram), were furnished by a series of specimens collected from St. Joseph and St. Mary's Lakes on the campus of the University of Notre Dame in the Spring of 1950. The eighteen bluegills ranged in standard lengths from 23 to 172 mm.; the eight warmouths, from 91 to 141 mm. The approximate ages (determined with a reasonable degree of accuracy by counting the annual growth rings in several scales from each specimen) varied from less than one year (in two specimens) to five years among the bluegills and from three to five years among the warmouths. Variation in size among individuals of the same age is indicated by the eight two-year-old bluegills whose standard lengths varied from 72 to 108 mm. and the three five-year-old warmouths ranging from 109 to 135 mm. Eleven bluegills were sufficiently matured to permit easy sex determination; five were females and six were males. The warmouths were not sexed.

The specimens were cleared and stained as described by Davis and Gore (1936). Observations and drawings were made with the aid of a low-power binocular dissecting microscope. Unless definitely stated to the contrary, the statements made in this paper are believed to be applicable to both species.

The typical amphicoelous vertebrae, including the urostyle (Whitehouse, 1910), number 29 with the exception of one bluegill and two warmouths with 30. The extra vertebrae in these three fishes are caudals. Generally there are 12 trunk and 17 caudal vertebrae. In two bluegills an extra trunk vertebra could be accounted for by the occurrence of the first haemal arch on the fourteenth rather than on the thirteenth vertebra; similarly an extra caudal in a warmouth resulted from the development of the first haemal arch on the twelfth rather than the thirteenth vertebra.

The "hourglass" centrum encloses a small-caliber cavity. There are no central fenestrations. In the caudal region the terminal convexities of each centrum appear bridged together on either side by a narrow strip of spongy-looking bone, leaving a hollow concavity underneath (Figs. 4A and 5A). In the trunk region of the warmouth these bridges between the ends of a centrum are ventral to the transverse processes on vertebrae 8 to 10 inclusive, and both ventral and dorsal to the transverse processes on vertebrae 11 and 12. From there caudad, there is only one on either side of each centrum—in a median position unobstructed by the presence of a transverse process (Figs. 4A and 5A). In the trunk region of the bluegill these bridges, ventral to the transverse process, are not so well defined. The centra toward either end of the vertebral column are shorter and they gradually lengthen towards the middle of the column, the maximum being attained by the eighth to the sixteenth vertebrae inclusively.

Ford (1937) pointed out that the functions performed by the atlas-axis complex in the higher vertebrates—attachment of the skull to the spinal column and provision of an axis on which the head moves—are in teleosts either assumed by the first vertebra or the first few vertebrae. Evans (1939) stated that in bony fishes the first two vertebrae differ from those behind them only in being a little shorter. They are indeed shorter and the first more so than the second. There are, however, other detectable differences. On the first vertebra of the two centrarchids studied here, there are three points of articulation with the skull: a round central concavity directed somewhat ventrad and two dorso-lateral projections meeting similar outgrowths from the skull (Fig. 1). A pair of sturdy, winglike, and somewhat lateral extensions of the centrum project caudad from each of the first two vertebrae. These are here designated as post-zygapophyses and are far more conspicuous than anything suggesting a pre-zygapophysis. There is a distinction here as compared with the remaining vertebrae where the pre- and post-zygapophyses are developments of the neural arch.

Developments from the neural arch (neural zygapophyses) are fairly well developed and functional on the trunk vertebrae (Fig. 2A and 2B). In the caudal region the neural arches are lower, though not so low in the warmouth as in the bluegill, and the anterior part is frequently reduced to a small antero-dorsad projection which fails to meet a similar tiny neural post-zygapophysis of the preceding vertebra (Fig. 5A and 5B). Analogous processes, haemal zygapophyses, are found but are poorly developed and nonfunctional on the haemal arches of some caudal vertebrae (Fig. 5A). The haemal

pre-zygapophyses are particularly weak on the first three caudals.

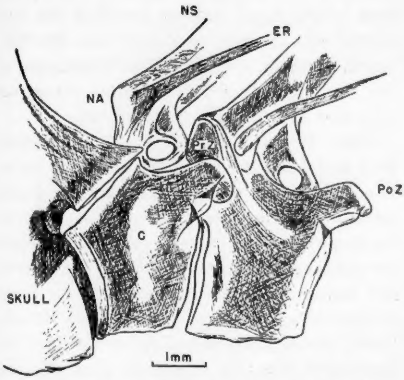


Fig. 1. First and second vertebrae of a two year old bluegill. C, centrum; ER, epipleural rib; NA, neural arch; NS, neural spine; PoZ, post-zygapophysis; PrZ, pre-zygapophysis.

of the first two vertebrae lie close to, but do not fuse with, the underlying centrum.) The arches terminate in typical neural spines except on the last three vertebrae. The neural arches occupy the entire length of each centrum. In the trunk region the neural spines are continuations of the neural arch at the posterior end of the centrum while in the caudal region the opposite condition obtains, the neural spine comes off the anterior end (Figs. 2 and 5). The neural spines of the anterior trunk vertebrae (varying from the first 11 to the first 14) lie in close approximation to the greater length of the radials of the dorsal fin. In some on each specimen it appears that the hollow surface of the neural spine receives the neighboring radial in a loose tongue-and-groove arrangement. On the first 8 or 9 vertebrae, the neural spines present their anterior surfaces to the corresponding radials, while for the next 4 or 5 it is the posterior surface which meets the radial. The neural arch from

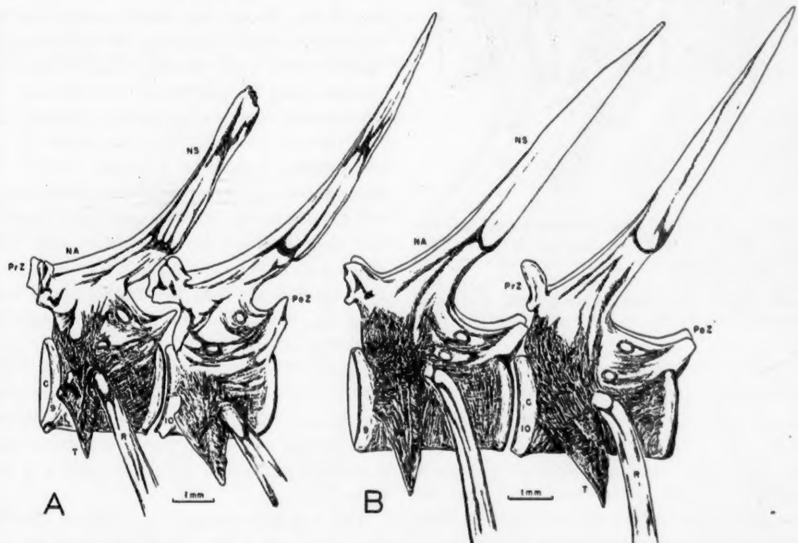


Fig. 2. Vertebrae 9 and 10 of a three year old warmouth (A) and a two year old bluegill (B). C, centrum; NA, neural arch; NS, neural spine; PoZ, post-zygapophysis; PrZ, pre-zygapophysis; R, rib; T, transverse process.

Except for the aberrant ultimate and penultimate vertebrae, there is a neural arch, formed of two distinct moieties, firmly ankylosed to the centrum of each vertebra. (Ford, 1937, wrote that in the typical percoid fish the neural arches

each vertebra from the third to the twenty-second inclusive is penetrated by two fenestrae. From the twenty-third to the last complete centrum the neural arch has but one fenestra.

Well developed haemal arches and spines are

present on each vertebra from the thirteenth to the twenty-sixth inclusive. (As mentioned above, the first haemal arch occasionally is found on the twelfth or fourteenth vertebra.) The haemal arches are only rarely fenestrated.

Transverse processes are present on the trunk vertebrae (Fig. 2), with the exception of the first two. They are consistently found on the first acudal and are not absorbed in the formation of the haemal arch but together with it make up a single structure (Figure 4). This makes it difficult to state with certainty that these apophyses[1] are haemapophyses, especially in the absence of complete transition stages found, for example, in salmon (*Salmo salar*), in which the

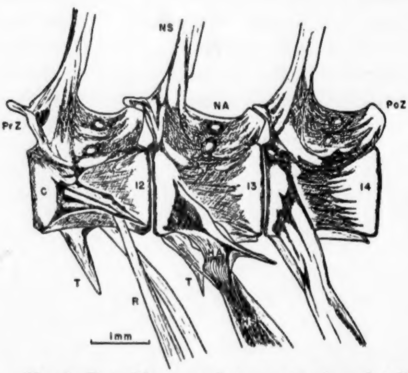


Fig. 3. Transition area between trunk and tail region showing 12th, 13th (first caudal), and 14th vertebrae of warmouth. C, centrum; HA, haemal arch; HS, haemal spine; NA, neural arch; NS, neural spine; PoZ, post-zygapophysis; PrZ, prezygapophysis; R, rib; T, transverse process.

haemal arches open up toward the middle of the column and the remaining basal stumps of the trunk region serve there for rib attachment. The apophyses here under discussion, probably best considered simply as transverse processes, apparently are excellent points for muscle attachment. The ribs are joined to them by ligaments near their proximal ends (Fig. 2).

Ribs are regularly present on the trunk vertebrae. In the bluegill, ribs are likewise present on the first caudal (with the exception of the cases in which the fourteenth vertebra is the first caudal). However, in the warmouth ribs are not found on the first caudal (Fig. 3), even in the single instance in which the first caudal was the twelfth rather than the thirteenth vertebra. (See Fig. 4 for comparison of the first caudal of *Chaenobryttus coronarius* with that of *Lepomis m. macrochirus*.)

Many teleosts, such as the salmon, possess both dorsal and pleural ribs on the same vertebrae. Evidently either type may be found directly attached to the centrum or to basapophyses. Without embryological evidence, the position of the ribs in relation to the muscles and coelom is the sole criterion for their being designated as dorsal or pleural ribs. Hyman (1942) stated that, according to the work of Emelianov, the ribs may shift their position with regard to the muscles during ontogeny, rendering their position in the adult an unsafe criterion for distinguishing between dorsal and pleural ribs. This evidently refers to the shifting of the pleural ribs to the dorsal position rather than vice versa. Since all of the ribs attached to the trunk vertebrae (except those on the first two) lie between the muscles and the peritoneum, they are apparently pleural ribs. But the possible shift of a true pleural rib to the position normal to a dorsal, i.e., in the myocommata, makes it somewhat hazardous to call the ribs on the first two vertebrae "dorsal," but their position in the muscles and their shape and direction indicate that they are of that type. Since they lie on the neural arch (Fig. 1), they might be properly designated "epineurals," following Bridge (1910) and Kingsley (1926). Similarly, one terms "epipleurals" the extra ribs found in these centrarchids attached to the first 8 pairs of pleural ribs. These epipleurals have the same size, shape and position in the myocommata as the epineurals.

The last 5 vertebrae are deflected dorsad; the penultimate and ultimate decidedly so. The last 3 are further modified in their relation to the caudal fin (Fig. 6). The most anterior of these, the antepenultimate, shows no readily discernible differences from those immediately preceding it other than the elongate epural and hypural bones. It is obvious that these latter are extensions of the neural and haemal spines, respectively, and show a transition stage be-

[1] The usage with regard to the terminology of the various types of vertebral apophyses is somewhat confused. For example, Hyman (1942) used parapophysis to mean a projection from the centrum for the attachment of the lower head of the two-headed ribs; Romer (1949) indicated that any transverse process serving for rib attachment is a parapophysis; Storer (1951) used the term evidently for any transverse process.

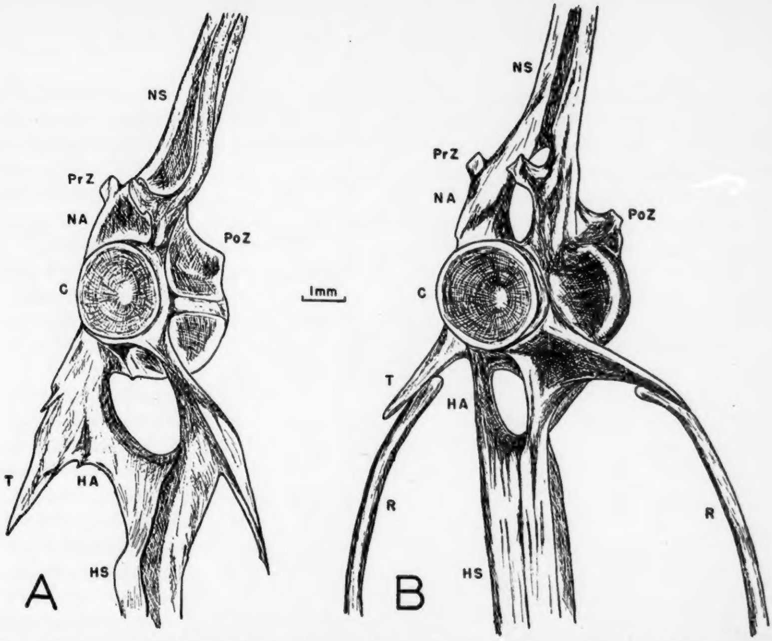


Fig. 4. First caudal vertebra of (A) a four year old warmouth and (B) a three year old bluegill. C, centrum; HA, haemal arch; HS, haemal spine; Na, neural arch; NS, neural spine; PoZ, post-zygapophysis; PrZ, pre-zygapophysis; R, rib; T, transverse process.

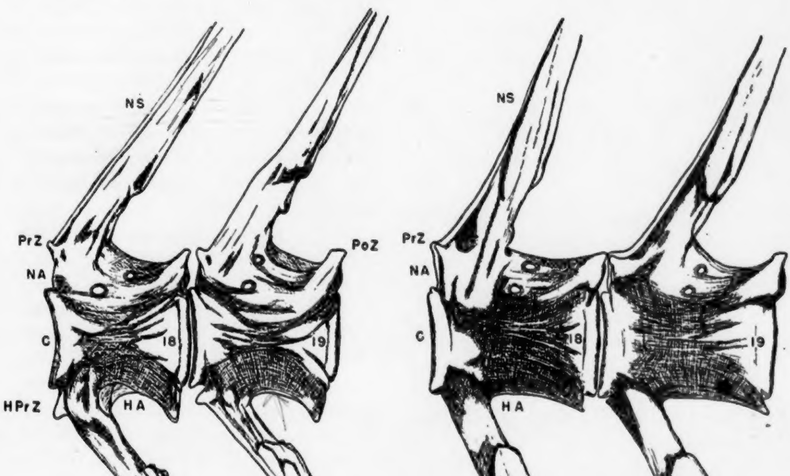


Fig. 5. Vertebrae 18 and 19 of (A) a three year old warmouth and (B) a two year old bluegill. C, centrum; HA, haemal arch; HPrZ, haemal pre-zygapophysis; HS, haemal spine; NA, neural arch; NS, neural spine; PoZ, post-zygapophysis; PrZ, pre-zygapophysis.

tween the normal spinous processes and the more characteristic epurals and hypurals. Ford (1937) adopted from Regan the term autogenous to describe bones which are closely applied to but not definitely fused with the centrum. Although not easily detected, the antepenultimate hypural is autogenous (Fig. 6).

In his work on the larval herring, Ramanujam (1929) found the penultimate vertebra to be formed by the fusion of two centra, and the double origin was further indicated by the presence of two hypurals. The smallest specimens used in this present study showed the bluegill and warmouth to have only a single centrum and one hypural for the penultimate

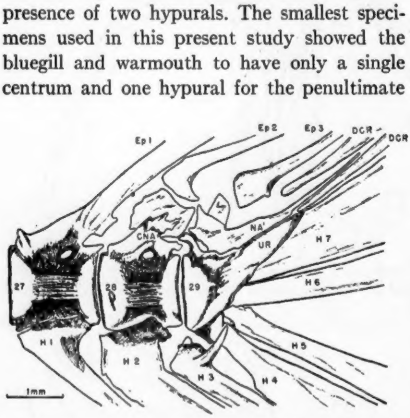


Fig. 6. The three terminal vertebrae (Nos. 27–29) of a two year old bluegill. CNA, crested neural arch; DCR, dorsal caudal radial; Ep1–Ep3, epurals; H1–H7, hypurals; NA′, extra neural arch; UR, urostyle.

vertebra. The neural arch bears a decided crest (Fig. 6) which varies considerably in size and shape among the specimens. Ford (1937) believed this crested condition of the neural arch of the penultimate vertebra to be common to the "Percomorphi." Rather widely separated from its neural arch is the long slender epural (Ep2). The hypural (H2) is likewise autogenous, greatly developed at its base, and widened slightly throughout its length (Fig. 6).

Ramanujam (1929) found that in the herring the urostyle and the bones associated with it are formed from the embryonic rudiments of three vertebrae, parts of which are either lost or greatly altered during ontogeny. Whitehouse (1910) had said that, although the urostyle appeared as simply a prolongation of the last centrum, it actually represents a fusion of several centra. Ramanujam (1929), however, found that the two most posterior centra of the embryo atrophied almost completely, except for a small remnant which together with a small piece ensheathing the terminus of the notochord are fused to form the styliform projection of the urostyle. Undoubtedly the formation of the urostyle varies to some extent among different groups of teleosts. The developmental origin of the urostyle cannot be exactly determined for the two centrarchids in these studies, though it evidently involves more than one vertebral segment.

The roughly cone-shaped urostyle has its somewhat broadly extended apex sharply deflected dorsad (Fig. 6). A vestige of a neural arch rises and bends craniad almost to touch a tiny backward extension from the neural arch of the penultimate vertebra. Four of the bones dorsad to the urostyle are identified but not with certainty. An autogenous epural and two dorsal caudal radials (Ep3 and DCR of Fig. 6) support the caudal fin rays as do the hypurals below. The fourth (NA′) has a broad base which lies free above the basal portion of the urostyle, and a slender projection from this base closely parallels the upward deflection of the styliform terminus of the urostyle. In his description of the caudal fin of *Serranus cabrilla*, Whitehouse (1910) said that a similar structure protects the delicate end of the spinal cord and probably represents one or more neural arches of vertebrae now absorbed in the urostyle. (See Fig. 6 for an unidentifiable oblong bone between NA′ and Ep3.)

Of the five hypurals associated with the urostyle, the most anterior (H3 of Fig. 6) lies free of any contact with the urostyle. Its base is still recognizable as a haemal arch enclosing a canal. From this base a spur-like process extends out and dorso-caudad, evidently serving for muscle attachment. This process is sometimes a tapering point (Fig. 6) or ends in a spear-head. In his observations of the centrarchids in the British Museum, Ford (1937) found the hooked hypural universally present. The next three hypurals have their bases much reduced and lie in close contiguity with the terminal shaft of the urostyle but are not ankylosed with it (Fig. 6). The most anterior of the three (H4) has a much broader elongate portion than the other two, with the middle one (H5) the narrowest of the three. The most posterior hy-

pural (H7) is considerably broader than the others and its proximal end is wedged in between the neighboring hypural and the upward flexure of the urostyle, to which it might possibly be fused. Each hypural fans out distad and the two most posterior ones at their proximal ends show no resemblance to a haemal arch.

Clothier (1946) found that in the goby, *Clevelandia ios*, as well as in two closely related forms, the vertebrae underwent considerable morphologic alteration during the period from hatching to almost adult sizes. The vertebrae of the bluegill and warmouth, however, showed no distinct morphologic differences between the smallest and the largest.

The series of two species of Centrarchidae examined shows their vertebral columns and associated bones to be similar in most details. The most notable exception is the presence of a pair of ribs on the first caudal of the bluegill and their absence on the same structure in the warmouth. Extra vertebrae are caudals. The occasional presence of the first haemal arch on the twelfth or fourteenth vertebra, instead of on the thirteenth, results in either an extra caudal or an extra trunk vertebra, respectively. There are no gradual transition stages between typical trunk and typical caudal vertebrae. The first haemapophyses form a complete arch and spine. It is quite possible that further examination of the skeletons of freshwater fishes might clear up some problems of relationship and prove of real taxonomic value.

Literature Cited

Bridge, T. W. 1910. Fishes. In *The Cambridge Natural History, 7: 139–537, figs. 91–324.*

Clothier, Charles R. 1946. Vertebral variation with size in *Clevelandia ios*. Copeia *(3): 113–16.*

Davis, D. D., and U. R. Gore. 1936. Clearing and staining skeletons of small vertebrates. *Field Mus. Nat. Hist., Tech. Ser., 4: 1–15.*

Evans, F. G. 1939. Morphology and functional evolution of the atlas-axis complex from fish to mammals. *Ann. New York Acad. Sci., 39: 29–104, figs. 1–14.*

Ford, E. 1937. Vertebral variation in teleostean fishes. *Jour. Marine Biol. Assoc. United Kingdom, 22 (1): 1–58.*

Hyman, L. H. 1942. Comparative vertebrate anatomy. 2nd Ed. *University of Chicago Press, Chicago, xx + 544, figs. 1–136.*

Kingsley, J. S. 1926. Comparative anatomy of vertebrates. *P. Blakiston's Son & Co., Philadelphia, 470 pp., figs. 1–435.*

Ramanujam, S. G. Manavala. 1929. The study of the development of the vertebral column in teleosts, as shown in the life-history of the herring. *Proc. Zool. Soc. London, 2: 365–414, figs. 1–28.*

Romer, A. S. 1949. The vertebrate body. *W. B. Saunders, Philadelphia, xvi + 643, figs. 1–363.*

Storer, T. I. 1951. General zoology, 2nd Ed. *McGraw Hill, New York, xxxiii + 832, figs. 1–560.*

Whitehouse, R. H. 1910. The caudal fin of the Teleostomi. *Proc. Zool. Soc. London, 1910: 590–629, 4 pls.*

Department of Biology, University of Notre Dame, Notre Dame, Indiana.

Conditioned Restrictions of Movement in Fishes, Fancied and Real

C. M. Breder, Jr. and Ethel Hafter Atz

THERE is a general belief, in lay circles at least, that if fishes are kept in a small bowl for a long time they will, when released in a pond or large tank, continue to move in a circular path for a more or less extended period. This notion appears in various guises from time to time and usually concerns goldfish. The inference is made that the fish "do not realize" that the transparent glass confining wall is no longer restricting their movement. Actually, such a fish usually swims rapidly away from the point of release. If the container is emptied very slowly and gently so as to frighten the fish as little as possible, there may be a period in which the fish very gradually leaves the container and moves off in an unhurried manner. Many observations of this have been made over an extended period of years, and actually with more favorable material than could be readily provided bv ordinary laboratory practice.

Many times during the twenty-two years

one of us spent at the old New York Aquarium, persons would bring in a bowl of goldfish which they were forced to relinquish for one reason or another. Such bowls of fishes, according to the donors, had been maintained for periods up to about five years. Perhaps the average would have been close to two years. None of these fishes was in the slightest deceived about the absence of the walls of the bowl. This specific item of behavior was watched for in all cases.

The very special case described by Breder and Rasquin (1951) is without bearing on the above considerations. In this instance, fishes returned to the bucket in which they had been held, when upon their release they were confronted both with a background they did not match and with the presence of predators. The present remarks refer to releasing fishes in environments which are not grossly inimical.

It has been clearly indicated by Breder (1943) and Breder and Gresser (1941) that the blind fish, *Anoptichthys*, has no, or at least inadequate, distance receptors concerned with the location of solids. That is to say, these fishes collide with stones and walls until they establish the location of such objects by some mechanism evidently involving memory of position. Certain behavior, noted when individuals were emptied into a large aquarium from fruit jars, led us to suppose that the alleged behavior of eyed fish might actually be present to some extent in these blind ones. To establish the validity of this idea, a glass cylinder of $5\frac{1}{4}$ inches diameter was placed standing in an aquarium, and two fully grown *Anoptichthys antrobius* Alvarez were put in it. After twenty-four hours the cylinder was gently withdrawn and the fish continued to circle for about ten seconds. Interestingly, this circling did not remain precisely over the exact spot covered by the cylinder, but gradually moved off to one side. When the fish encountered "new" bottom, they appeared agitated as evidenced by faster swimming and twitching movements, and they slowed down when they re-entered the area which had been included within the cylinder. A second trial of the same two fish, confined as before but for forty-eight hours, yielded similar results. It could not be said, however, that the restricting influence lasted longer or gave other evidence of being stronger.

A third trial with confinement of ninety-six hours gave less marked results. There was hardly any circling, and the fish quickly passed to other areas. There was, however, a marked tendency for the fish to remain in the general location of the cylinder, and for from five to ten minutes later a more or less frequent return was made by both fish to the area which had been encompassed by the cylinder. This may merely mean that the fish, on this third trial, were becoming accustomed to the whole procedure. The aquarium used had a floor area of 2 feet by 1 foot and the cylinder, $5\frac{1}{4}$ inches in diameter, had been placed with its center over a point 6 inches from one end on the lengthwise center line of the aquarium. The half area (1 foot by 1 foot), also centered at this point, covered virtually the entire travels of the two fish for at least two days after their release. Before this series of experiments was begun, the fish wandered over the entire available area.

Whether or not there is any significant difference in behavior depending on length of confinement could only be revealed by extended studies along this line.

Young *Anoptichthys* of about 15 mm. standard length were similarly confined for twenty-four hours but showed no such behavior when the cylinder was removed. They immediately charged off in various directions. It is notable in this connection that these fishes at this size rub their chins along a surface to a considerable extent. Larger and older fish rarely do this, but maintain a fairly definite distance from a surface with which they are familiar. Ordinarily, when these larger fish do collide with a surface, they rebound from it and do not travel along in a rubbing contact with it. Therefore, when removing the cylinder from around the small fish, care was exercised to withdraw it when the fish were not sliding along its inner surface.

The implication would seem to be that in the younger fish the establishment of a good "spatial memory" had not yet taken place. These smaller fish are growing very rapidly and it is conceivable that the adult pattern of avoiding obstacles cannot appear until the speed of brain growth has been substantially slowed. This idea could be made the subject of experimental study.

Twenty-four hour confinement of eyed *Astyanax mexicanus* (Filippi) and blinded ones

(blind for at least three years) merely produced what might be called a state of panic, naturally more notable in the eyed fish. In both instances one fish jumped out. This did not occur in any of the other experiments.

Blinded *Carassius auratus* (Linnaeus), blind for two years, behaved more like the cavefish after a number of experiences with the cylinder than did their eyed relatives. This would seem to be related to the relative "placidity" of the cavefish and goldfish as compared with *Astyanax*. Optically intact *Ameriurus nebulosus* (LeSueur) simply swam away when the cylinder was lifted. This form is notably thigmotactic.

It thus appears that fishes which are to a large extent optically motivated encounter no difficulty in responding appropriately to release from a small transparent container. On the other hand, normally blind fish lacking such visual cues, and depending on the more diffuse non-visual ones, show some sluggishness of reaction to a release from such a container.

Another general belief which also appears from time to time is that if a glass partition is placed in an aquarium with a pike or similar fish on one side, and some small minnows placed on the other, after a time the pike will cease in its efforts to try to catch the minnows. When this occurs, it is then allegedly safe to remove the partition and the pike will live in peace with the smaller fish. This idea is evidently rooted in the reports of Möbius (1873) and Triplett (1901). Both deliberate and casual repetitions of these experiments with a variety of species have led only to the destruction of the minnows. An abundant literature, however, is available which indicates not only that the fishes have the ability to form conditioned reflexes, but also that the individual behavior traits control the ability of fishes to do so (Milligan, 1916; Bull, 1928, 1929, 1930, 1935a, 1935b, 1936, 1938). Both Möbius (1873) and Triplett (1901) suggested from their experiments with pike and perch, respectively, that these fish had within a few months formed a conditioned reflex to the "pain" of bumping into a glass partition in an attempt to get at minnows on the other side. As a result of this conditioning, removal of the partition resulted in no attack on the minnows, and in addition, as reported by Triplett, the perch did not venture beyond the point where the partition formerly had been. In the light of more recent work, however, certain factors in both these earlier experiments must be considered: a measure of intensity of the conditioning stimulus ("pain," actually a collision with the glass) was not objectively known; the conditioning stimulus was, in effect, negative as both "pain" and no "pain" were associated with no food.

Another explanation of the Möbius experiment was offered by Bateson (1890) who suggested that the behavior of the pike could be explained on the basis of habituation by constant association.

It can be shown with less predatory forms at least, that fishes of the same kind can become habituated to certain foods and to smaller members of their own kind which otherwise might be eaten. For example, a small group of goldfish were brought into a house from a small lily pond late in the fall for wintering. These fish had been feeding all summer on insects and to a considerable extent on their own offspring. In fact there was only one young fish of that year found when the pool was emptied. Since it was obvious that in the confines of a relatively small aquarium (3 feet by 1½ feet by 1½ feet) the small fish would be quickly eaten, it was placed in another aquarium with a population of *Gambusia a. affinis* (Baird and Girard), the largest of which was not over twice its length. About four months later it was noticed that the goldfish (1 inch standard length) was in a rather poor condition. It had been picked on by the *Gambusia* so that the fins were ragged. During this time all the fishes had been fed exclusively on prepared dried food. Since the tank containing the large goldfish (4 to 5 inches standard length) was well grown with plants, the little individual was slipped unobtrusively into the aquarium after the larger fish had been deliberately overfed. For the first day the small fish stayed as far away from the much larger fish as possible and kept among the plants. Several times the next day it ventured forth and was chased by one or more of the larger fish. For the first week it was fed separately from the large fish. The procedure was to feed the large fish first, and while they were engaged, feed the smaller, with a smaller size of granule. On the third day the small fish recognized the place where its food was placed and subsequently was there at

feeding time. By the end of the first week this was a well established pattern. After the small fish had fed, it would hesitatingly join the larger group to feed with them also. By the end of the second week it had become one of the group, and was evidently so "recognized" by the rest—as a fellow aggregation-mate and not as a food object—although the largest individual could easily have swallowed the small fish. It may be added parenthetically that the omnivorous voraciousness of fully healthy goldfish will induce them to strike at practically any sufficiently small moving object, including their own kind or even gas bubbles arising from some subterranean decomposition. These same individual fishes in the fall of the previous year ate a considerable number of their offspring when they were carelessly added to the aquarium, both year classes being slightly but proportionally smaller.

While there is no satisfactory evidence that predaceous fishes may be trained not to feed on minnows by the method alleged, there is good evidence that habituation to foods and fellows among aggregating fish may determine whether a given individual is to be treated as a companion or a food object.

Related to this restrictive phenomenon are the changing attitudes of individual fishes to others under differing circumstances. For example, black bass will ordinarily pursue and catch smaller sunfish, but the latter, when on their nests, have been seen to chase away black bass large enough to swallow them (Breder, 1936). Similarly, cichlids have been observed (Breder, 1934) attacking human hands. Such defensive behavior is well known to persons working with living fishes. The reaction of the larger fish, that of fleeing promptly from a fish which would otherwise be dealt with as a food item, seems to be rooted in a deep-lying primary reaction common to many animals, to flee from anything approaching rapidly, and then later perhaps to investigate. These and related matters have been discussed in detail for aggregating fishes by Breder and Halpern (1946) and for schooling fishes by Breder (1951). This basic tendency is evidently over-ridden when the territoriality of the nest is established. *Eupomacentrus leucostictus* (Müller and Troschel), which normally lives in empty shells, whether nesting or not, displays such behavior at nearly all times. Juveniles of this species will also show this behavior at a certain stage of development. The behavior of *Eupomacentrus* is distinctly different from that of the small goldfish described above. The goldfish did not "intimidate" the others by dashing at them, but slipped "unobtrusively" into the group, and beat a hasty retreat if approached by one of the others.

A transparent barrier such as the side of an aquarium or a partition therein evidently presents a problem to the fish mind which varies widely in different species. Some forms, notably various oceanic fish, such as mackerels and certain individuals of other species, such as small tarpon, seem to be incapable of learning to react appropriately to a glass wall and continually attempt to swim through it, sometimes to their own destruction. Naturally most fishes well suited to aquarium life soon give up such attempts. While there would seem to be nothing present in the normal environment of fishes in any way resembling such vertical transparent walls, sharp temperature gradients may act in a roughly similar fashion. Breder (1951) described such a reaction in herring. These fish responded to a temperature gradient in a manner which closely resembled their turning back sharply from a glass wall.

Literature Cited

Bateson, W. 1890. The sense-organs and perceptions of fishes, with remarks on the supply of bait. *Jour. Mar. Biol. Assoc. United Kingdom, n.s., 1: 225–56.*

Breder, C. M., Jr. 1934. An experimental study of the reproductive habits and life history of the cichlid fish, *Aequidens latifrons* (Steindachner). *Zoologica, 18 (1): 1–42.*

——— 1936. The reproductive habits of the North American sunfishes (Family Centrarchidae). *Ibid., 21 (1): 1–48.*

——— 1943. Problems in the behavior and evolution of a species of blind cave fish. *Trans. New York Acad. Sci., ser. 2, 5: 168–76.*

——— 1951. Studies on the structure of the fish school. *Bull. Amer. Mus. Nat. Hist., 98 (1): 1–28.*

Breder, C. M., Jr., and E. B. Gresser. 1941. Further studies on the light sensitivity and behavior of the Mexican blind characin. *Zoologica, 26 (28): 289–96.*

Breder, C. M., Jr., and E. Halpern. 1946. Innate and acquired behavior affecting the aggregation of fishes. *Physiol. Zool., 19: 154–90.*

Breder, C. M., Jr., and P. Rasquin. 1951. A further note on protective behavior in fishes in reference to background. Copeia, *(1): 95–96.*

Bull, H. O. 1928. Studies on conditioned response in fishes. Part I. *Jour. Mar. Biol. Assoc. United Kingdom, n.s., 15: 485–533.*

——— 1929. On the nature of purposive move-

ment in fishes. *Rept. Dove Mar. Lab., n.s., 18: 39–46.*

——— 1930. Studies on conditioned responses in fishes. Part II. *Jour. Mar. Biol. Assoc. United Kingdom, n.s., 16: 615–37.*

——— 1935a. Studies on conditioned responses in fishes. Part III. Wavelength discrimination in *Blennius pholis* L. *Ibid., 20: 347–64.*

——— 1935b. Studies on conditioned responses in fishes. Part VI. The formation of a conditioned motor response in *Blennius pholis* L. to a change in direction of current flow. *Rept. Dove Mar. Lab., ser. 3 (3): 37–48.*

——— 1936. Studies on conditioned responses in fishes. Part VII. Temperature perception in teleosts. *Jour. Mar. Biol. Assoc. United Kingdom, n.s., 21: 1–27.*

——— 1938. Studies on conditioned responses in fishes. Part VIII. Discrimination of salinity changes by marine teleosts. *Rept. Dove Mar. Lab., ser. 3 (5): 19–35.*

MILLIGAN, H. N. 1916. On the educability of three rocklings and a sea-bullhead. *Zoologist, 20: 289–93.*

MÖBIUS, K. 1873. Die Bewegungen der Thiere und ihr psychischer Horizont. *Schrift. Nat. Ver. Schleswig-Holstein, 1: 111–30.*

TRIPLETT, N. 1901. The educability of the perch. *Amer. Jour. Psychol., 12: 354–60.*

THE AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK 24, NEW YORK.

Ichthyological Notes

ERYTHROCYTE COUNTS AND HEMOGLOBIN DETERMINATIONS FOR TWO SPECIES OF SUCKERS, GENUS *CATOSTOMUS*, FROM COLORADO.—This investigation was intended to be a study of erythrocyte variation in two species of *Catostomus* as a function of altitude, but so many technical difficulties were encountered that such plans had to be discarded. In view of the paucity of available information about sampling fish blood, erythrocyte counts, and hemoglobin content, it is felt that the small amount of such data accumulated is worth presenting. Field work was carried on in Boulder County along the east slope of the Front Range of the northcentral section of Colorado, where altitudes vary from 5,000 to more than 12,000 feet. Laboratory work was done in the Department of Biology at the University of Colorado and this paper constitutes Contribution No. 19 of the Limnology Laboratory, Biology Department, University of Colorado.

Two species of suckers of the genus *Catostomus* inhabit this section of Colorado. *C. commersoni suckleyi* Girard, the western white sucker, is the predominant stream sucker of the plains and foothills up to an elevation of about 7,500 feet, where it is replaced by *C. catostomus griseus* Girard, the western longnose sucker, in streams at higher elevations. The white sucker, however, is the predominant species of the lakes and reservoirs of both the plains and the high mountains.

Great difficulty was experienced in drawing and preserving satisfactory blood samples for a later count. About 350 specimens of *C. commersoni suckleyi* and about 125 of *C. c. griseus* were utilized in getting 9 and 3 samples respectively, on which valid, trustworthy counts were obtained. Almost invariably the blood coagulated, hemolyzed, or crenated during handling. A variety of methods for taking and holding the blood was tried, but none gave consistently satisfactory results.

The best results were obtained by drawing and immediately diluting blood taken directly from the macerated heart, using a standard diluting pipette. A thin coating of anti-coagulant was distributed in the pipette by evaporating to dryness one-half milliliter of solution containing four milligrams of anti-coagulant per milliliter. Potassium oxalate, ammonium oxalate, and sodium citrate were tried as anti-coagulants with no noticeable difference in their effects. When sufficient anti-coagulant was used to deter coagulation noticeably, perceptable shrinkage of the erythrocytes occurred. All the methods in which the blood was held undiluted proved unsatisfactory as no suitable means was found for preventing coagulation or hemolysis. The use of the diluting pipette under field conditions was awkward, since speed was essential in drawing the blood into the pipette. The blood had to be drawn exactly to the mark with a very minimum of adjusting, and immediately diluted; otherwise the result was a string of coagulated blood. Quite often the blood would hemolyze as it was diluted, for no apparent reason. Other workers (Powers, Rostorfer, Shipe, and Rostorfer, 1938, Jour. Tenn. Acad. Sci., 13: 220–45) have attributed this difficulty to the contamination of the sample with small amounts of tissue fluid.

The diluted samples that were satisfactorily drawn were sealed with rubber caps and transported to the laboratory where the counts were made within 4 hours. Standard red cell diluting pipettes were used and dilutions were made in the ratio of 1:200 using several standard solutions (Hayem's, Hayden's, Gower's, and isotonic citrate solution). Since

none of these gave satisfactory results, several variations were tried. The one that gave the best results had the following composition: 10.0 grams sodium sulfate, 2.5 grams sodium chloride, 1.5 grams sodium citrate, 50.0 milliliters of glacial acetic acid, and water to make 500 milliliters. A Spencer bright-line counting chamber with improved Neubauer ruling was used. Two counts were made for each sample and an average taken. Total length,

TABLE I

ERYTHROCYTE COUNTS IN TWO SPECIES OF *Catostomus*

Species, Date, Elevation, Location	Total length, cm.	Weight, grams	Year of life	Sex	Erythrocytes in millions*
Catostomus commersoni suckleyi					
5/23/50	19.5	120	IV	M	1.666
5100 feet	20.5	125	IV	M	1.162
South Boulder Cr.	21.0	130	IV	M	1.240
	22.0	135	IV	M	1.130
	23.0	165	IV	M	1.280
6/9/50	11.0	20	III	M	1.430
5100 feet	11.0	22	III	M	1.500
South Boulder Cr.					
5/13/50 5150 feet Baseline Reservoir	23.0	155	III	M	0.790
5/14/50 5200 feet Allens Lake	27.0	265	III	M	1.027
Catostomus catostomus griseus					
4/20/50	13.0	30	II	M	1.570
5300 feet	14.0	50	II	M	1.190
St. Vrain Cr.					
5/12/50 9000 teet Beaver Reservoir	18.0	85	III	F	1.027

* Average for 9 specimens of *C. c. suckleyi*, 1.204; for 3 specimens of *C. c. griseus*, 1.262.

weight, age, and sex were also determined. Those samples on which a valid, trustworthy count was obtained are presented in Table I. A much larger body of data was discarded as unreliable.

The erythrocyte counts are very variable, and it is improbable that any variation caused by the factor of altitude would be great enough to be detected owing to the large number of other variables and the inherent error in the counting technique, which is probably in the neighborhood of plus or minus 4 percent, even by an experienced investigator. Ponder (1948, Grune and Stratton, N. Y., 398 pp.) stated that two erythrocyte counts (for man) by an average investigator cannot be held significantly different unless they vary by more than 14 percent.

A survey of the literature indicates that there is a considerable difference in blood characteristics from one genus to another. This is apparent in the erythrocyte counts, the size of the cells, the clotting time, and the hemoglobin content. Field, Elvehjem, and Juday (1943, Jour. Biol. Chem., 148: 2–6), for example, found that trout blood was more resistant both to hemolysis and immediate coagulation than carp blood. In the present study the average coagulation time was only about 2 to 4 seconds.

TABLE II

HEMOGLOBIN DETERMINATIONS IN TWO SPECIES OF *Catostomus*

Species, Date, Elevation, Location	Total length, cm.	Weight, grams	Year of life	Sex	Hb in grams per 100 ml.
Catostomus commersoni suckleyi					
6/9/50 5100 feet South Boulder Cr.	11.0	20	III	M	10.9
Catostomus catostomus griseus					
4/20/50	13.2	40	II	M	11.2
5300 feet	14.0	50	II	M	11.0
St. Vrain Cr.	15.2	65	III	M	'1.9

A few hemoglobin determinations were attempted with a Spencer Hemoglobinometer. These were made in the field with blood taken directly from the living fish. Serious difficulty was encountered in making this determination because of the rapid coagulation of the blood, and about 35 fish were utilized in getting four successful determinations (Table II). No information on hemoglobin values for *Catostomus* was found in the literature surveyed.

For their helpful suggestions and criticisms of this manuscript, sincere appreciation is extended to Dr. William A. Spoor of the University of Cincinnati, and Dr. Max Katz of the U. S. Public Health Service in Cincinnati.—LAWRENCE J. HENDRICKS, *Wildlife Conservation Building, University of Missouri, Columbia, Missouri.*

OVIPARITY—THE MODE OF REPRODUCTION OF THE WHALE SHARK, *RHINEODON TYPUS*.—In forty years' study of the whale shark, *Rhineodon typus* Smith, I have had the opportunity to see but one specimen in the flesh—a male. Not until recently has anything of help in the literature

come to light bearing on the manner of reproduction of this great fish. All other large sharks are viviparous, and it was logical to assume that *Rhineodon*, the largest of all sharks (growing to 60 feet), also is viviparous. One could not conceive of such a giant laying eggs.

In their encyclopaedic work on sharks, Bigelow and Schroeder (1948, Fishes of the Western North Atlantic, Vol. I (Sharks): p. 188) stated that "Development [is] probably ovoviviparous." Their bibliography of *Rhineodon* titles covers nearly two pages and lists not merely literature found in journals, but much out-of-the-way literature, such as the Ceylon Administration Reports of 1912–13 in Marine Biology. Herein was found (p. E 44) an interesting bit of information by T. Southwell, but they apparently overlooked its significance: "March 18, 1910. Dutch Bay–'*Rhineodon typicus*' ... very ripe ovary. Oviduct full of eggs, 16 cases counted, same form as in dogfish." Unfortunately, Southwell does not give the size of the whale shark, and, worse, he does not name the dogfish, and, worst of all, he does not figure and describe the egg cases. And, so far as we know, he did not preserve the egg cases with their embryos. Since Southwell was an English naturalist and surely was acquainted with many English fishes, his "dogfish" was probably one or the other of the common spotted dogfishes of European waters of the genus *Scyliorhinus*, which is known to lay eggs with tendrils. But if Southwell had an Indian dogfish in mind, it is quite possible that he referred to the genus *Scyllium*, which also lays eggs.

Thus the whale shark is presumably an egg-layer. It is hoped that some ichthyological reader of this note may have, somewhere, somewhen, the opportunity to dissect a female *Rhineodon* and to obtain, figure and describe the eggs and embryos; and may thus effectually settle the question of the manner of reproduction of this great shark.—E. W. GUDGER, *American Museum of Natural History, New York 24, New York.*

ADDITIONAL NOTES ON THE DISTRIBUTION OF THE BLACKFIN TUNA (*PARATHUNNUS ATLANTICUS*).—Until recently the recorded northern limits of occurrence of blackfin tuna, *Parathunnus atlanticus* (Lesson), had been off the coast of Bermuda, and off Florida along the United States coast (Beebe and Tee-Van, 1936, Zoologica, 21 (3): 177–94). In 1951 we reported one specimen taken off the coast of North Carolina (1951, COPEIA, (3): 248), and thus extended considerably its reported northern range along the United States coast. Since that report, we have obtained additional information on the distribution of the species.

In October 1948, a tuna (29 cm. in length) was caught about 75 miles south of Martha's Vineyard (40° 04′ N., 70° 42′ W.) by trolling from the Woods Hole Oceanographic Institution research vessel CARYN. (Cruise C-3 under the direction of William C. Schroeder). Our recent examination of this specimen, now in the Museum of Comparative Zoology of Harvard University, has shown it to be *Parathunnus atlanticus*. This capture represents, as far as we can determine, the most northerly record for the species. On the strength of this definite record and reports of occasional catches of the species by anglers off New Jersey (related to us by Louis S. Mowbray, Director of the Bermuda Government Aquarium and Al Pflueger, Taxidermist of Miami, Florida), it seems that the concept of the northernmost limit of blackfin tuna should be changed, possibly to something like "ranging occasionally northward as far as Cape Cod."

Near the other end of its known range, one of us (Mather) found blackfin tuna quite abundant in the northwestern corner of the Caribbean in January and February of 1950. (Observation during a cruise made in the motor sailer IRMAY under charter to the Institution for Andean Research, Inc. Dr. Lionel A. Walford directed the fishery work for a portion of this cruise.) Specimens were taken and several schools were seen among the Bay Islands (16°–17° N., 86°–87° W.) and at Cozumel Island (20° 30′ N., 87° 00′ W.), and other schools believed to be the same species were sighted off the coasts of Honduras and British Honduras. Several individuals were collected and are now at the Harvard Museum of Comparative Zoology. The 21 fish taken ranged from 32 to 59 cm. in standard length, and all of those seen appeared to be within these limits.

While the species has been reported from many islands of the West Indies by Beebe and others (1928, Zoologica, 10 (1): 1–279; 1935, *Ibid.*, 19 (6): 209–24; 1936, *Ibid.*, 21 (3): 177–94) and from Courtown Key in the southwestern Caribbean by Fowler (1944, Acad. Nat. Sci. Phila., Monogr. 6: 1–583) we believe that the specimens reported here represent the first record of this tuna in the northwestern Caribbean. Furthermore, the many schools observed and the testimony of local fishermen that their presence was not unusual indicate that blackfin tuna frequent this area in considerable numbers. (This paper is Contribution No. 606 from the Woods Hole Oceanographic Institution.)—FRANK J. MATHER, III, *Woods Hole Oceanographic Institution*, AND HOWARD A. SCHUCK, *U. S. Fish and Wildlife Service, Woods Hole, Massachusetts.*

FIRST RECORD OF THE PERCOPSID FISH *COLUMBIA TRANSMONTANA* FROM IDAHO.—On April 18, 1952, the writers collected one specimen of the sand roller, *Columbia trans-*

montana Eigenmann and Eigenmann, which was caught in the fish trap in the Washington Water Power Company dam on the Clearwater River at Lewiston, Nez Perce County, Idaho. Since that date, 124 additional specimens have been taken: 29 in the fish ladder, and the remainder with an electrical shocker from the shallows above the dam and at the mouth of Hatwai Creek, two miles upstream. These specimens range from 27 to 87 mm., total length; six of the larger adults are sexually mature and had not spawned on May 9. These specimens were taken from the Clearwater River four to six miles above its confluence with the Snake River. As far as can be determined, they constitute a new record of this species from Idaho and from the Snake River drainage. Jordan and Evermann (1896, Bull. U. S. Nat. Mus., 47 (1): 785) recorded it from the Columbia River as... "locally abundant at the mouth of the Umatilla and Wallula rivers; our specimens taken by Thoburn and Rutter in the Wallula at Walla Walla." Umatilla is in Oregon and the second locality was miswritten for Walla Walla River at Wallula, Washington. In the summary by Schultz and DeLacy (1936, Mid-Pac. Mag., 11 (1): 66), the Willamette River, Oregon, was the only other locality recorded for the species. We are indebted to Dr. Robert R. Miller, of the Museum of Zoology, University of Michigan, for information on distributional records. —VIRGIL S. PRATT, *Idaho Cooperative Wildlife Research Unit, University of Idaho, Moscow,* AND CHARLES R. WHITT, *Idaho Fish and Game Department, Lewiston, Idaho.*

OCCURRENCE OF THE LAMPREY *LAMPETRA AEPYPTERA* IN THE TOMBIGBEE AND PASCAGOULA DRAINAGES, MISSISSIPPI.—Specimens of a very small lamprey collected in the Tombigbee and the Pascagoula River systems in Mississippi were recently identified by Dr. Milton B. Trautman as *Lampetra aepyptera* (Abbott). These specimens represent an extension of the known range of this species, which according to Raney (1952, COPEIA (2): 98–99) was previously from the upper Ohio River system to the Wabash River system, Indiana, and on the Atlantic slope, from the Potomac River to the Neuse River system, and in the Alabama River system, Georgia.

The Mississippi collections consist of ten adults collected on January 28, 1937, in the backwater of Okatoma River, a tributary of Leaf River in the Pascagoula River system; one adult collected in December, 1940, by R. M. Freeman, in Ponta Creek, a tributary of Sucarnoochee Creek in the Tombigbee River drainage; and one ammocoete from Water Prong Creek in the Pascagoula River drainage, collected by W. H. Turcotte, on June 21, 1946. These specimens range from 90 to 104 mm. in total length with an average of 95.6 mm. The myomere count varies from 51 to 56, and averages 53.6. They all have degenerate teeth.

In commenting on the specimens Dr. Trautman says that he has never seen such small lampreys and that he considers it quite possible that an adequate series might show these to be specifically, or subspecifically, distinct from *aepyptera*. Although the specimen from Water Prong Creek is an ammocoete, and as such is unidentifiable, it has been provisionally identified as *aepyptera* on the basis of the locality and the low myomere count of 51.—FANNYE A. COOK, *Museum of Natural History, Mississippi Game and Fish Commission, Jackson 6, Mississippi.*

SHARKS AND SAWFISHES IN THE AMAZON.—Records of marine fishes which penetrate the waters of the largest of all rivers are relatively rare. This is especially true of elasmobranchs other than the freshwater sting rays of the genera *Potamotrygon, Elipesurus* and *Disceus*. In fact, no *Pristis* is recorded in Fowler's recent checklist of Brazilian freshwater fishes (1948, Arq. Zool. Est. São Paulo, vol. 6), and the only shark mentioned is one from the island of Marajó, at the mouth of the Amazon. This is Boulenger's record of *Carcharhinus porosus* (Ranzani).

On the other hand, it is well known in the Brazilian Amazon country that sawfishes are found in the lower river, below Manaus, but the only mention I have found in the literature is an obscure one by the late Prof. Alipio de Miranda-Ribeiro. In one of a series of articles on the zoogeography of Brazil (1937, O Campo, ano 8, no. 93: 59) he mentioned in a footnote that *Pristis* is found in some of the lagoons on the left (north) bank of the Amazon. He evidently had seen no specimens, nor did I; and the species is yet undetermined.

I have heard that sharks ascend the main river and are occasionally caught at Manaus, almost 1000 miles from the sea. However, until recently I had no concrete evidence. In Washington in 1950, Señor Felipe Ancieta, of the Fish and Game Department of Perú, told me he had a photo of a shark taken in the Peruvian Amazon, and he has recently sent it to me. The information accompanying the photo states that the shark was caught at Iquitos in October, 1943. Iquitos is approximately 2300 miles (by the river) from the sea. The photo is not very good and shows a three-quarter ventral view of an adult male *Carcharhinus* a little over six feet in total length. The head is in the shadow, but the blunt snout is visible. The first dorsal fin cannot be seen, but enough of the tip of the second dorsal is visible to show that this fin originated anterior to the front of the anal fin. The lower caudal lobe is relatively sharp; the tip of the upper

lobe is hidden. The pectorals are reasonably long and falcate but not narrow. Of course nothing can be seen of a dorsal ridge, if any is present.

On going through Bigelow and Schroeder's account in "Fishes of the Western North Atlantic," various characteristics visible in the photograph definitely exclude all American Atlantic species of *Carcharhinus* save *leucas, milberti, nicaraguensis, obscurus* and *springeri.* There seems comparatively little chance that it is one of the last three, however, purely on geographical grounds, for *obscurus* is a pelagic shark and the other two are not known nearly so far south as the Amazon. It is quite impossible to determine from the photo whether the animal is more like *leucas* or *milberti*, but the known freshwater habits of the former make it seem very likely that the Peruvian shark is *Carcharinus leucas* (Müller and Henle).—GEORGE S. MYERS, *Natural History Museum, Stanford University, California.*

NEW DISTRIBUTION RECORDS FOR FISHES OF THE SAVANNAH RIVER BASIN, SOUTH CAROLINA.—The following fishes, not hitherto reported in print from this part of South Carolina, have been obtained from one or more of the six streams (namely, Upper Three Runs, Four Mile Creek, Pen Creek, Steel Creek, Hattie Creek and Lower Three Runs) in the Savannah River Operations Area located in Aiken and Barnwell counties. Collections were made between July 2, 1951 and May 19, 1952 by the University of South Carolina research team on Contract No. AT (07–2)–11, Atomic Energy Commission with W. E. Hoy as project leader. The letter A indicates that the species was collected in Aiken County, B Barnwell County, and AB both counties. A: *Anguilla rostrata* (LeSueur), *Chologaster cornuta* Agassiz, *Mesogonistius chaetodon* (Baird); B: *Amia calva* Linnaeus, *Ameriurus natalis* (LeSueur), *Fundulus dispar lineolatus* (Agassiz), *Acantharchus pomotis* (Baird), *Lepomis punctatus punctatus* (Valenciennes), *Lepomis gibbosus* (Linnaeus), *Lepomis microlophus* (Günther), *Hololepis barratti* (Holbrook), *Labidesthes sicculus vanhyningi* Bean and Reid; AB: *Esox americanus* Gmelin, *Esox niger* LeSueur, *Umbra pygmaea* (DeKay), *Hypentelium nigricans* (LeSueur), *Ameriurus nebulosus marmoratus* (Holbrook), *Schilbeodes leptacanthus* Jordan, *Schilbeodes marginatus marginatus* (Baird), *Schilbeodes mollis* (Hermann), *Aphredoderus sayanus* (Gilliams), *Chaenobryttus coronarius* (Bartram), *Elassoma zonatum* Jordan, *Lepomis cyanellus* Rafinesque (introduced), *Lepomis macrochirus purpurescens* Cope, *Lepomis marginatus* (Holbrook), *Lepomis auritus* (Linnaeus), *Boleosoma nigrum* (Rafinesque), and *Hadropterus nigrofasciatus* Agassiz.—H. W. FREEMAN, *Department of Biology, University of South Carolina, Columbia 1, South Carolina.*

A SECOND SPECIMEN OF THE ANGELFISH GENUS *CENTROPYGE* FROM THE ATLANTIC.—Woods and Kanazawa (1951, Fieldiana-Zoology, 31: 636, fig. 135), described a new species of angelfish, *Centropyge argi*, collected in 93 fathoms on Argus Bank, Bermuda. This species was found to be very similar to *Centropyge fisheri* (Snyder) from Hawaii and is the first species belonging to this genus to be described from the Atlantic.

A second specimen of *Centropyge argi* has recently been received from the U. S. Fish & Wildlife Service, through the courtesy of Mr. Stewart Springer. This specimen was collected by the M/v OREGON, Station 591, Lat. 23° 24′ N., Long. 87° 09′ W., on Campeche Banks, about 65 miles north of Cabo Catoche, Yucatán. It was taken from the stomach of a snapper caught on a handline in 40 fathoms. It is in excellent condition and is described as follows, with the counts and proportions of the original description of the species in parentheses for comparison: standard length 53.5 (44.5) mm.; dorsal rays XIV,16 (XV,15); anal rays III,17 (III,17); pectoral rays 15/16 (14/15); scale rows from upper edge of gill opening to base of caudal rays 42 (45). Depth of body 2.58 (2.33), length of head 3.97 (3.42), both in standard length; eye 3.12 (2.77), interorbital 3.71 (3.61), length of last dorsal spine 1.64 (1.63), length of middle caudal rays 1.53 (broken in holotype), length of pectoral fin 1.22 (1.21), length of pelvic fin spine 1.54 (1.89), depth of caudal peduncle 2.4 (2.5)—all in length of head.

The preorbital (mistakenly called suborbital in original description) has one long, curved spine with a shorter spine anterior to it and a very short spine at the base of the latter on the left side; on the right side there are two long, curved spines of almost equal length with one short spine both above and below; preopercular denticulate, one of every few serrae enlarged, a large spine at angle reaching almost to the pectoral fin with a shorter downward-curved spine basally; lateral line rising sharply, following close along base of dorsal and terminating close under the base of the last dorsal rays.

The color before preservation was described as bright yellow on the anterior portion with the posterior portion blue. The preserved specimen has head, breast, and upper sides pale yellowish-white, with the nape dusky; a distinct round black spot just above pectoral fin and a little posterior to its base; the body brownish-black, from a line running from origin of dorsal to insertion of pelvic spine posteriorly; vertical fins also brownish-black; pectorals pale; pelvics dusky.

The shape of the body, kind and size of spines on the head, most of the proportions and counts, as well as coloration, of the Campeche Bank specimen so closely resemble the Bermuda specimen

that both are regarded as the same species, and the slight differences are ascribed to variation of the two widely separated populations, or to individual variation.

Specimens of *Centropyge fisheri* were collected off Oahu in depths of 27 to 29 fathoms and 14 to 43 fathoms. The Atlantic specimens are also from habitats deeper than usual for other species of Pomacanthinae.—LOREN P. WOODS, *Chicago Natural History Museum, Chicago 5, Illinois.*

FISHES USING CTENOPHORES FOR SHELTER.—The authors, while on a field trip in Mississippi Sound in the vicinity of Biloxi, Mississippi, in the summer of 1951, found small fishes on several occasions *in* and under jellyfishes and ctenophores. Though several other authors have reported these same fishes under medusae, the only record of fish inside Ctenophora was reported in the 1913 Guide to the Zoological Station at Naples as follows: "Inside the cavity of *Beroe* or in the pendent stalk of medusae are often seen small fish which the apparently delicate organism dissolves and digests." We differ with this interpretation because we observed the small fishes to swim in and out of the ctenophores, which were also of the genus *Beroe.*

The only specimen of the fish *Palinurichthys* sp. to be taken in the extensive collections of the past two summers was found in a *Beroe.* One member of the crew also reported observing a *Syngnathus* in a *Beroe,* and this fish was also not observed with any of the medusae but was frequently collected in the seine. *Chloroscombrus chrysurus* (Linnaeus) and *Hemicaranx amblyrhynchus* (Cuvier) were found frequently in or with both *Beroe* and medusae. The *Hemicaranx* was never found, in our experience, except intimately associated with either *Beroe* or medusae. For every *Hemicaranx* there were probably three or four *Chloroscombrus* in this situation. Only one fish, *Peprilus alepidotus* (Linnaeus), was found with medusae and not in *Beroe.* About seven of these were observed.

Under one large medusa (about five inches) were seen twelve small fish about one half inch in length; these were mostly *Chloroscombrus,* but some *Peprilus* were present. Though these were not captured, one such medusa with its fish was brought in and was found to have five *Chloroscombrus* and two *Peprilus.* Most of the medusae involved were *Dactylometra* but there were also some fishes under a similar unidentified medusa, though no perceptible preference was observed. Any floating object appears to be about equally attractive to fishes.

We wish to thank Loren P. Woods, of the Chicago Natural History Museum, who has assisted in this study.—JAMES E. MATTHEWS AND HURST H. SHOEMAKER, *Department of Zoology, University of Illinois, Urbana, Illinois.*

Herpetological Notes

ANTIVENIN AVAILABLE FOR THE TREATMENT OF SNAKEBITE.—There is considerable disagreement regarding the amount of benefit derived from the use of antivenins in the treatment of bites by venomous snakes. Despite the conflicting opinions, involving gross underestimates on the one hand and extreme exaggerations on the other, two points are clearly indicated. First, there is great therapeutic hazard in the indiscriminate use of these antivenins. Most of this hazard arises from the sensitivity of some individuals to horse serum from which the antivenins are prepared. Marked reaction to the horse serum may literally make the "cure worse than the bite" and terminate in sudden death, or produce less acute signs of distress. The second point is that in individuals with no sensitivity to horse serum the careful use of antivenins has produced impressive, often spectacular, beneficial results. Fortunately, most people are not sensitive to horse serum and, therefore, discriminate use of antivenins is indicated in most cases involving grave consequences resulting from the bite of a venomous snake. Wherever possible, it is advisable to have the serum administered by a doctor. In serious cases intravenous injection may be necessary or desirable. Many of the antivenins are packaged with the inclusion of materials needed to test quickly the individual's sensitivity to horse serum.

With the demonstrated value of antivenin in some cases of snakebite, serum definitely constitutes a necessary insurance for anyone whose activities bring him in contact with live venomous snakes. At the New York Zoological Park we endeavor to maintain at all times a stock of the available antivenins as a precaution in the event of a snakebite involving our personnel. Most of these antivenins must be replaced from time to time, since the liquid preparations retain their effectiveness for only a few years. The dehydrated serum is effective for a longer period of time than the liquid preparation. This stock does not constitute a source

of supply for distribution to other institutions or individuals, except in extreme emergency. It is purely for our own protection.

We have received numerous requests for information relating to the types of antivenin available and where they may be obtained. The requests have come from professional herpetologists, as well as non-herpetological institutions and individuals. Thus it seems desirable to list the different kinds of antivenins now being produced and to give, for each, the address of the manufacturing institution. Insofar as possible we have tried to make contact with all of the institutions that produce antivenins for commercial distribution. There are a few laboratories that manufacture an antivenin for private usage but, from some, it may be possible to obtain small quantities of sera at specified times. We have listed only the regular producers of antivenins. We would appreciate learning of any additional sources of antivenins that are not on this list.

The antivenins are listed below according to the continent that is the homeland for the venomous snake against whose venom the antivenin is made.

Africa

1. Polyvalent serum for African Elapids and Viperids.
2. Polyvalent serum for venomous snakes of West and Equatorial Africa (*Bitis* and *Hemachatus*).
3. Anti-Cobra serum for Egypt and India.

These antivenins are produced by The Pasteur Institute of Paris, Service of Serotherapy, 36 Rue du Docteur-Roux, Paris XV, France. All three of the antivenins are polyvalent serums produced through the use of mixed venoms of several species. Numbers 1 and 2 are made from mixtures of strongly hemotoxic and neurotoxic venoms, whereas No. 3 is made from venoms that are predominantly neurotoxic. The latter is also advertised as being effective against the bites of the Asiatic cobras.

The FitzSimons' Snake Park, P. O. Box 1413, Durban, South Africa also manufactures a polyvalent antivenin similar to serum No. 1. In the production of this antivenin the "mixed venoms of African snakes" are employed, and it is advertised for use in the case of "bites by any species of venomous snakes" of Africa.

4. Polyvalent "Anti-Snakebite Serum" for southern Africa.

This antivenin is produced against the venoms of the puff adder (*Bitis arietans*) and the Cape cobra (*Naja nivea*). It is advertised by the manufacturer as being useful against the venoms of other venomous species found in southern Africa. This antivenin is made by the South African Institute for Medical Research, Hospital Street, Johannesburg, South Africa.

Asia

5. Polyvalent "Anti-venom Serum" against the venoms of the cobra (*Naja naja*) and Russell's viper or Daboia (*Vipera russelli*).

This serum is manufactured by the Central Research Institute, Kasauli, India. It is reputedly an effective serum against the very strongly hemotoxic venom of Russell's viper, as well as the strong neurotoxins of the cobra venom, but is said to be more effective against the former than against the latter. It is also reported to be effective against the strong hemorrhagin of the venom of the saw-scaled viper or Phoorsa (*Echis carinata*).

6. Polyvalent Antivenin for venomous snakes of Southeastern Asia.
7. Specific anti–*Agkistrodon rhodostoma* Antivenin.
8. Anti-cobra Antivenin, against both common cobras (*Naja naja*) and king cobras (*Ophiophagus hannah*).
9. Anti-viper antivenin, for Russell's viper (*Vipera russelli*).

Serums 6, 7, 8 and 9 are the products of the Queen Saovabna Memorial Institute, an affiliate of the Pasteur Institute, Bangkok, Thailand. The antivenins manufactured here are specific for the three most important venomous snake species of southeastern Asia. In addition a polyvalent serum is produced to cover the bite of any species of venomous snake found in this area.

The Haffkine Institute, Parel, Bombay 12, India, manufactures a polyvalent serum similar to No. 5, but including factors effective against the venoms of the saw-scaled viper (*Echis carinata*) and the common Krait (*Bungarus fasciatus*).

The Pasteur Institute, Djalan Pasteur No. 9, Postbox 47, Bandung, Indonesia, produces a polyvalent antivenin similar to No. 6, but specifically made for the venoms of *Bungarus fasciatus*, *Naja tripudians*, and *Agkistrodon rhodostoma*.

Antivenin No. 8 is very similar to the anti-cobra serum of the Pasteur Institute of Paris which is effective against the venoms of the common cobras (*Naja naja*) and the king cobras (*Ophiophagus hannah*). However, because of the use of an unknown proportion of venom from African cobras in No. 3, the two serums probably differ in effectiveness. At the date of this writing, the Institute for Infectious Diseases of the University of Tokyo, Japan, has temporarily stopped the manufacture of a polyvalent serum against the venoms of the Habu (*Trimeresurus flavoviridis*) and the Mamushi (*Agkistrodon halys*). It is hoped that production of this antivenin will be resumed in the near future.

Australia

10. Tigersnake Antivenin.

Manufactured by the Commonwealth Serum Laboratories, Royal Park, Victoria, Australia. This serum is a specific antivenin against the venom of the tigersnake (*Notechis scutatus*), but is also recommended as an effective treatment, in varying dosages, against the venoms of all the important venomous snakes of Australia.

Europe

11. Anti-viper Antivenin.

Produced with the venom of the European asp viper (*Vipera aspis*). Reputedly effective against the venom of various species of European vipers (*Vipera*). Manufactured by The Pasteur Institute of Paris, Service of Serotherapy, 36 Rue du Docteur-Roux, Paris XV.

North America

12. North American Antisnakebite Serum.

Manufactured by Wyeth Incorporated, Philadelphia 3, Pa. This antivenin is produced with a mixture of venom from several species of North American venomous snakes of the genera *Agkistrodon* and *Crotalus*. It does not contain any factor for coral snake (*Micrurus*) venom.

South America

13. Polyvalent Anti-pit viper Antivenin. This serum is produced against the venoms of the common Brazilian Jararaca (*Bothrops jararaca*) and the South American rattlesnake (*Crotalus durissus terrificus*).
14. Anti-Bothropic Antivenin. Produced as a specific serum against the venom of the common Brazilian Jararaca (*Bothrops jararaca*), but reportedly effective against the venoms of other species of *Bothrops*.
15. Anti-Crotalic Antivenin. A specific serum for use against the strongly neurotoxic venom of the South American rattlesnake (*Crotalus durissus terrificus*).
16. Anti-elapid Antivenin. A serum manufactured to combat the effectiveness of the venom of several species of South American coralsnakes (*Micrurus*).
17. Anti-lachetic Antivenin. This is a specific serum for the bite of the bushmaster (*Lachesis muta*).

Antivenins Nos. 13, 14, 15, 16 and 17 are produced by the Instituto Butantan, Caixa Postal 2123, Rua da Gloria 34, São Paulo, Brasil. Serums similar to Nos. 13, 14, 15 and 17 are also produced by Instituto Pinheiros, Caixa Postal 951, Rua Teodoro Sampaio 1860, São Paulo, Brasil. Serums similar to Nos. 13, 14 and 15 also are produced by the Instituto Vital Brazil, Caixa Postal 28, Rua Vital Brazil Filho, 64, Niteroi, Brasil.

Several other South American Institutions have produced antivenins within recent years. However, we have been unable to obtain specific information regarding any other antivenin now being produced on a regular basis.

Summarizing the information given above, there is at least one antivenin available for the most important venomous snakes of each continent. The continents where the incidence and seriousness of snakebites are more important from a medical standpoint have several antivenins available.

Of the seventeen different antivenins produced, seven are polyvalent sera produced through the use of a mixture of venoms. These polyvalent sera provide protection against the venoms of several different species of snakes, but perhaps are not so effective against a particular venom as are the specific antivenins. Ten of the available antivenins are considered specific sera, since they are produced entirely or primarily through the use of venom from a single species of snake. These are equally divided between the predominantly hemotoxic and the predominantly neurotoxic venoms.—James A. Oliver and Leonard J. Goss, *New York Zoological Society, 185th Street and Southern Boulevard, New York 60, New York.*

OBSERVATIONS ON THE EGGS AND LARVAE OF THE SALAMANDER *BATRACHOSEPS PACIFICUS MAJOR*.—The eggs and larvae of *Batrachoseps pacificus* have never been described. Adults of this species were seen beneath boards and cement blocks adjacent to a house at 1420 East Mountain Street, Pasadena, California, but a daily search for their eggs, initiated on November 23, 1950, following several days of rain, was unsuccessful. Beginning on December 15, in the hope that surface oviposition might be induced, a garden sprinkler system was turned on for short daily periods. On December 20, a clutch of salamander eggs was noted beneath a small, flat, wooden box measuring 17½ by 19 inches. This box was near a raised sprinkler head and the daily waterings had kept the soil beneath it quite damp. The eggs had not been noted between 9 AM on December 19 and 1 PM on December 20, when they were found. At 1 PM on December 21 the eggs were reexamined. There were thirteen, deposited in a loose group beneath a corner of the sheltering box. An adult *B. pacificus* 125 mm. long was present a few inches away. Five of the eggs were free and the remaining eight were in four separate pairs connected by peduncles measuring 5.8, 9.0, 11.0 and 14.8 mm. The outer capsules were brownish because of adhering soil particles, but the yellowish yolk was

visible through them. The eggs were nearly uniform in size, measuring 5.8 to 6.0 mm. in diameter to the surface of the outer capsule. One was removed for dissection, leaving twelve *in situ*. On December 23, 14 eggs were counted, and another was removed. On January 18, 1951, 15 eggs were found, and one ruptured outer capsule with some jelly adhering to its inner surface. Thus, a total of 18 eggs were discovered.

The two eggs dissected had essentially the same structure. The outer capsule was pale amber; it was thin and tough and retained its shape when

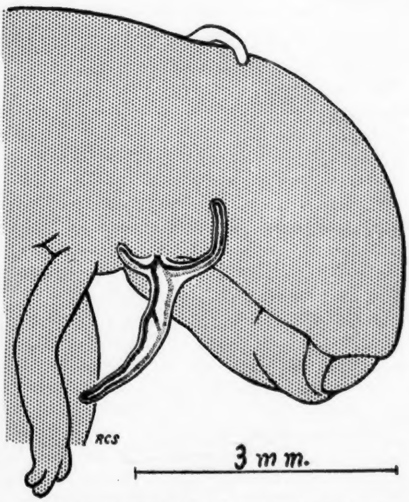


Fig. 1. Dorsal aspect of the gill in the embryo of *Batrachoseps pacificus major.*

removed. On either side were remnants of the peduncles or roughened scars where they had been broken off. The inner capsule was thick, and was composed of a crystal clear, viscous jelly, the removal of which exposed the chorion. Two eggs were sent to Dr. Robert C. Stebbins of the Museum of Vertebrate Zoology, University of California. One was dissected by him and the other was allowed to hatch. The egg structure as described in his notes of January 30, 1951, was the same as noted by me. It agrees in all except one detail with the description of the eggs of *B. attenuatus* given by Snyder (1923, Copeia 121: 86–8) and Maslin (1939, *ibid.*, (4): 209–12). These authors found two inner jelly layers rather than one, although Maslin (*loc. cit.*) stated that they were scarcely separable. No suggestion of a third layer was noted by Stebbins or me.

All the eggs dissected contained advanced embryos. These had well developed eyes and nasal grooves. Both fore and hind limbs had four digits, the inner and outer visible as rounded swellings, the second and third larger and more attenuate. Prominent, but simple, trilobed gills were present, and active circulation was observed in the vascular loops. In all specimens the central lobe was the largest (Fig. 1). This agrees with the gill structure of *B. attenuatus* as figured by Snyder (*loc. cit.*), although Emmel (1924, Amer. Jour. Anat., 33: 401, fig. 46) showed all three lobes as being approximately the same size. An embryo dissected from the egg on December 21 was 18 mm. long. This measurement is only an approximation, as the individual was curled about the yolk mass and moved its tail spasmodically when I tried to straighten it. Stebbins measured two embryos. One, dissected from the egg on January 30, 1951, was 20.15 mm. long. The other emerged during the night of January 30, and was 20.2 mm. long when measured the following day. Three recently hatched individuals measured by me on January 26 and 28 were 17, 18 and 19 mm. long.

On January 18, seven eggs were taken indoors and kept in a covered bowl of damp earth. At 8:15 AM on January 26, a newly hatched salamander was found in the bowl a few inches from the collapsed egg. Two more hatched on the morning of January 27, and three between 6:30 and 10:30 PM on January 28. The seventh egg failed to hatch. All the newly emerged larvae were fairly active and crawled about slowly when exposed to the rays of a desk lamp. The first individual to hatch righted itself when turned on its back, and threw its body into S-shaped curves when prodded. Two individuals, when handled, responded with "snap coils" typical of *Batrachoseps*; but these were single movements and the animals remained coiled without further response after the initial one.

The coloration of the larvae varied within narrow limits. All had dark venters and a broad stripe of bright reddish brown extending from the nape over the dorsum. In some, this stripe extended over the entire tail whereas in others it extended over the anterior third only. The dorsal stripe was not solid but consisted of intermingled brown and grayish black patches. This is suggestive of the dorsal coloration of adults of *B. p. major*, in which bright reddish brown patches are scattered over the dorsum and dorsal surface of the tail. Identification of these specimens was difficult because of their dark ventral coloration, and they were sent alive to Dr. Stebbins for further study. In a letter dated July 11, 1951, he notified me that the last of the young had died. He further stated: "They had reached sufficient size, however, to convince me they were *pacificus*. Several of them had begun to show marked reduction of the ventral caudal guanophores." The locality at which the eggs were found is in the range

of *B. pacificus*. As many as three adults of *pacificus* were seen at one time under the box where the eggs had been discovered, but no *B. attenuatus* were found there.

The embryos contained in the eggs on December 21 correspond approximately to the 103-day-old stage of *Bactrachoseps wrighti* as figured by Stebbins (1949, COPEIA (3): 165, fig. 1). Hatching in *wrighti* reared under laboratory conditions occurred after 133 days. Hatching of the eggs of *B. pacificus* occurred between 37 and 39 days after they were discovered; if the time of development is roughly the same in the two species, the embryos were approximately 100 days old when found. This would indicate that oviposition occurred at about the middle of September, a period ordinarily characterized by high temperatures and low rainfall in the Pasadena area. That this may be the normal time for oviposition is indicated by my finding two apparently recently hatched individuals measuring 23 and 21.5 mm. on January 4 and 23, respectively. Both were under a board about 100 feet from the box under which the eggs were found. Since the soil beneath the box was inspected at least once daily for nearly a month before the eggs appeared, it seems unlikely that they had been overlooked repeatedly during this period. It is possible that the female had carried the eggs throughout most of their development and did not oviposit until conditions were favorable for their continued development outside the body. However, this represents such an extreme departure from the known breeding habits of the Plethodontidae that it seems unlikely. It is possible that the eggs had been deposited below the surface of the soil and that continued sprinkling of the area had caused a subsoil accumulation of water detrimental to their continued development. The female may have brought the eggs to the surface where the drainage was better and where standing water did not accumulate. The fact that thirteen eggs were found on December 21, fifteen on December 23, and eighteen on January 18, might indicate that they were brought to the surface over a rather lengthy period.

Stebbins and Lowe (1949, COPEIA (2): 126) suggested that *Batrachoseps wrighti* is the form from which *B. pacificus* arose. Regarding *B. attenuatus*, they stated "It seems likely that it originated from *pacificus*, or at least passed through a *pacificus*-like stage in its development before reaching its present worm-like condition." The close relationship of *attenuatus* and *pacificus* is evidenced by the similarity in the gill structure of the embryos of these two species as opposed to that of *wrighti*. Stebbins (*loc. cit.*) noted that the gill of the embryo of *wrighti* consists of two primary divisions diverging from a common base, and that each division gives off three to five subsidiary lobes, each with a single vascular loop. The simple, trilobed gill of *pacificus* (Fig. 1) is similar to that of *attenuatus* as figured by Snyder (1923) and Emmel (1924).

I wish to express my thanks to Dr. Stebbins for drawing the accompanying text figure, for making available to me the notes which he made on the eggs and larvae forwarded to him, and for his identification of the larvae. All the material on which this paper is based has been deposited in the collections of the Museum of Vertebrate Zoology, University of California.—JOHN DAVIS, *Moore Laboratory of Zoology, Occidental College, Los Angeles, California.*

HABITS AND MINIMUM TEMPERATURES OF THE TOAD *BUFO BOREAS HALOPHILUS*.

—In western North America *Bufo boreas* has a distribution extending from Alaska to Baja California. It is also found from the lowlands into the high mountains to at least 10,000 ft. Throughout most of the northern and high altitude parts of this distributional range, freezing temperatures occur during most of the year. The object of the present study was to determine what adaptations in habits and physiology exist that enable the animals to meet the demands of a cold environment.

During 1951, some observations were obtained of *Bufo boreas halophilus* on Eagle Point at Big Bear Lake, California. The elevation here is 6,750 ft. and well within the Transition zone, the dominant plants being *Pinus jeffreyi* and *Artemisia tridentata*. The area experiences low daily minimum temperatures throughout the year, for it is located within a valley characterized by frequent thermal inversion. The summer of 1951 was unusual in that almost 6 inches of rain fell here.

Active toads were seen from March 24 to October 21, when observations ended. No body temperature or microclimatic measurements were made upon the active toads until September and October. During March the toads were active to some extent even though freezing temperatures occurred at 4 feet above the ground by 7:00 PM. Snow patches were present, and at night the ground froze to a depth of 1 to 2 inches. During the daytime and throughout the freezing part of the night, the toads remained underground in gopher and ground squirrel holes in which mid-day temperatures in sunny locations were 7° C. at 6 inches depth and 4.8° C. at 12 inches.

On April 20, great numbers of toads were congregated about the lake's edge, spending the day within gopher holes, under logs and overturned boats. Hard frosts still occurred every night with freezing temperatures commencing about 9:00 PM. Adult toads were observed alongside the lake until June 3, but by July 22, the date of the next visit, the toads had left the lake margin for the open forest.

Here they were active until October 21, the date of the last visit. At this time the weather was again severe and its effects were recorded.

The affinity of the toads for rodent holes is probably the chief factor that enables them to survive in large numbers under the known climatic conditions. The ground provides adequate insulation from extremes of temperature, both hot and cold. During the summer months, ground surface temperatures regularly reach at least 60° C. On October 19 two captured toads were left exposed on the ground surface during the night and were found dead and frozen solid by morning with body temperatures of −2°C. Frequently toads have been observed crouching in surface depressions among sage brush at the lake during the coldest part of a night. The time required to chill the body of a big toad might allow it to reach a more favorable den.

While excavating dens of *Citellus lateralis bernardinus*, the golden-mantled ground squirrel, it was found that during October over half the occupied dens also contained toads as well. The toads were at depths of 4 inches to 2 ft. within passages up to 6 ft. long.

The usual procedure at night was to drive a car slowly along the numerous dirt roads of the area. The toads are so common that, if they are active, some are always seen. The captured animals were held to the ground by their legs, and temperature was recorded by means of a Schultheis rectal thermometer especially made for small animal work. Temperatures at the approximate center of the animal were made by inserting the thermometer deeply into the cloaca. By moving the mercury bulb to the dorsal or ventral region of the animal it was possible to obtain values helpful in indicating the sources of heating and cooling in the animal's environment. The substrate temperature itself was taken by barely inserting the thermometer under the surface of the soil. The relative humidity of the toads' microclimate, based upon the dew point reached at an air temperature of about 5°C., was near 100 percent.

On October 19 and 20, they emerged from rodent holes by 5:45 to 6:00 PM. both days, suggesting a fine photosensitivity.

Body temperatures of active bufos varied from 12.0°C. just after emergence to 3.0° toward the end of the activity period on a cold night. A series of simultaneously taken body and environmental temperatures for three nights shortly before activity ceased showed the following averages: the deep cloacal temperature in the dorsal half of the body was 4.9°C., while the deep cloacal temperature in the ventral half of the body was 5.3°; the air temperature at one inch above the ground was 2.4°, while that at the ground surface was 5.2°. Thus, the dorsal surface is affected by the air, while the ventral surface is more affected by the substrate temperature.

When the air is colder than the sub-surface, the highest body temperatures are present when the toads emerge from the rodent holes. As a rule the body temperatures become lower with time, until the minimum activity point is reached at about 3°C. or possibly a little lower. The lower few inches of air appear to be the main determinant of toad activity, since both the ground and animal are affected by this layer. Within the toad, however, there is a temperature interaction between this air layer and the ground surface giving the toad its effective temperature.

An average of environmental temperatures, recorded immediately following the complete disappearance of the toads from surface activity, indicated the air temperature at 4 ft. above ground to be 2.0°C., the air temperature at 1 inch above to be 1.4°, and the substrate surface temperature to be 2.8°.

For three nights the toads completely ceased surface activity after 4½ hrs., 3 hrs., and 1 hr., respectively, of evening wandering. The temperature conditions at the end of each of these periods were similar, suggesting a close relationship of toad activity to environmental temperature.

The above observations permit the following conclusions. (1) The toad *Bufo boreas halophilus* is active at night throughout the year as long as temperatures over 3°C. prevail within the toad's microclimate. (2) The minimum body temperature for normal activity is about 3°C. Below this the toads retire, and at about −2°C. the animals freeze solid and die. Their affinity for rodent holes allows them to exist in great numbers in what could otherwise be climatically a very unfavorable habitat. (3) There is an interplay between air and substrate temperatures within the animal which governs its internal temperature. (4) When near freezing temperatures occur quickly after sunset, the toads are active only so long as it takes their bodies to cool from the rodent burrow temperature to 3°C. (5) Their critical minimum body temperature and the volunatry minimum body temperature (1944, Cowles and Bogert, Bull. Am. Mus. Nat. Hist., 83: 261–96) are very close together, probably not more than 2–3°C. apart. (6) This species is very light sensitive and becomes active in the evening at approximately the same time, night after night. (7) The toads and golden-mantled ground squirrels apparently exist together in harmony and it is thought that *Thomomys* and toads may have a similar relationship.

The writer wishes to express thanks to Dr. Raymond B. Cowles, Professor of Zoology in the University of California, Los Angeles, for suggestions

and help.—DON P. MULLALLY, *7620 Lexington Avenue, Los Angeles 46, California.*

OBSERVATIONS ON THE EARLY LIFE HISTORY OF THE LIZARDS *SCELOPORUS GRACIOSUS VANDENBURGIANUS* AND *GERRHONOTUS MULTICARINATUS WEBBI.* —Four females of *Sceloporus g. vandenburgianus*, captured on June 26, 1930, at Bluff Lake, San Bernardino Mountains, California, laid four eggs each in the early part of July. Three eggs were found on July 10 while still fresh and were put in a moist chamber at room temperature. One egg was still alive on August 4 and measured 21 x 12 mm; the blood vessels and dark eyes were plainly visible. On September 2, from it hatched a young lizard 6.2 cm. in total length. This date of hatching is within the normal time for young lizards to appear in their mountain habitat.

On October 12, 1943, at Idyllwild in the San Jacinto Mountains, a young of the year was captured measuring 6.7 cm. (28 mm., body + 39 mm., tail). It ate small mealworms readily. On November 4, it weighed 0.99 g.; by January 19, 1944, it had grown to 1.27 g.

The sizes of these lizards are comparable to those of *S. g. gracilis*, as given by Stebbins (1944, Ecology 25: 241–42).

A female alligator lizard, *Gerrhonotus multicarinatus webbi*, 11 cm. in total length, was captured on June 8, 1941, in Los Angeles, California. On June 17 about 8:00 AM, she started egg laying. The entire clutch of 12 eggs showed embryonic development. The eggs averaged 16.4 x 9.3 mm., and the thin red disc of the embryonic area was 14 x 8 mm. This date of egg laying is a month earlier than that recorded by Gander (1931, COPEIA (1): 14), more advanced also than for any of the breeding females recorded by Fitch (1935, Trans. Acad. Sci. St. Louis, 29: 23), and a month earlier than recorded by Shaw (1943, COPEIA (3): 194).

The eggs were kept in a humid atmosphere at room temperature, mainly 72–78°F., but occasionally reaching 83°. Forty-two days later, on July 29, the eggs averaged 16.7 x 11.3 mm. From the smallest egg (16 x 9.5) was removed an embryo with head and body length measuring 25 mm. On August 9, from an egg 17 x 11 mm. was taken an embryo of 30 mm. from snout to anus, with tail length of 50 mm. and yolk sac of 10 x 5 x 2 mm.

The remaining ten eggs hatched on August 16–17, sixty to sixty-one days after being laid. No yolk was left, but thin albumen was present. In hatching, the snout and lower jaw were first extended from the split in the shell. Movements of the floor of the mouth varied from four to eleven times a minute. Occasional swallowing brought the chin down to the shell, thereby causing the gradual emergence of the back of the head. The lizards remained with head partially out for some time, even several hours. If a lizard saw movement or the egg was touched, the head was pulled back into the shell. In one egg the head remained retracted for five hours; then when the rear of the egg was touched, the lizard slid out up to its hind legs and, shortly after, came out completely. The entire hatching process was a gentle affair. At hatching, the lizards averaged in head and body length 33 mm. (range 30–35) and tail length 57 mm. (range 50–62). Fitch (*op. cit.*) found young of the year measuring 33.5 to 35.5 mm. in head and body length. Shaw (*op. cit.*) found newly hatched young measuring 26 to 35 mm., with an average of 32.2.

The lizards, when completely out of the shells, became very active—blinking, testing the surroundings with their tongues, and crawling or jumping unhesitatingly. Davis (1945, COPEIA (2): 116) mentioned the activity of the lizard *Leiolopisma laterale* just after hatching, and Lewis (1946, COPEIA (3): 155) found the newborn of the ovoviviparous *Gerrhonotus coeruleus principis* to be very active. Werler (1951, Zoologica, 36: 39) wrote of the activity of newly hatched *Sceloporus grammicus microlepidotus*. In contrast to this, Franklin (1944, COPEIA (4): 250) found the young of the brown watersnake inactive until after molting, 18 to 48 hours after birth, and March (1945, COPEIA (3): 169) recorded the newly hatched *Crotalus basiliscus* as quiet throughout the first day.

During the next three months the juvenile lizards fed readily on tiny larvae of beetles, adult *Drosophila*, and small moths. Water was drunk eagerly from a pipette, and often the lizards tried to reach the meniscus through the side of the pipette. Usually after drinking, they sat with head up for a few minutes. Very characteristic also was the weaving of the head from side to side when the lizards were about to pounce on the pipette for water, or on food, or on each other.

Growth in three months averaged 4 mm. in body length (range 2–7 mm.) and 8 mm. in tail length (range 5–17 mm.). Three lizards had their tails broken; one in the second week, one in the fourth and again in the twelfth, and one in the eighth. These breaks were the result of being pounced upon by another member of the family. Three lizards shed skins during the eighth week. In these three, and in one other that was not known to have shed, there began to develop, in the fifth week, a color pattern like the adult, with white bars on the entire lateral area of the trunk and with large black spots on the neck. In December the food supply was insufficient. Two died and the others were killed.—S. R. ATSATT, *Department of Zoology, University of California, Los Angeles, California.*

ERYTHRISM IN THE SALAMANDER *PLETHODON CINEREUS CINEREUS*.—It has been known for some time that uniformly red or erythristic individuals occur among normal populations of *Plethodon c. cinereus*. Reed (1908, Amer. Nat., 42: 460) reported on two specimens (with a third that escaped before it could be described) from New York State: one from Buffalo, caught September 9, 1905, and one from Beesemer (now Besemers, south of Ithaca) caught April 27, 1907. The specimen from Buffalo was found "under a piece of bark in a dry and rather open woodland," elevation 1,000 ft. The exact habitat of the specimen from Besemers was not described, although it is mentioned that the locality is at an elevation of 800 ft. Normal specimens, both of the red- and the lead-backed phases, as well as "intermediates" between all three phases, were found in the general area. Reed and Wright (1909, Proc. Amer. Phil. Soc., 48: 403) reported finding one pure red individual at Chautauqua, New York, in the summer of 1908.

Barbour (1914, COPEIA, 10: 3–4) reported one specimen from Cohasset, Massachusetts, that was found under the bark of a hemlock log. The red coloring was explained as follows: "This species .... will be seen to show scattered minute red dots in the black areas, showing that the red pigment is not really confined to the mid-dorsal region. It probably exists along with the black pigment wherever this occurs, but only shows when the more dense black pigment is absent." He suggests using the term "erythristic" for this phase. Bishop (1941, Bull. N. Y. State Mus., 324: 200) mentioned that he found one uniformly red specimen at New Salem, New York, on March 26, 1925. Burt (1945, Trans. Kansas Acad. Sci., 48: 204) said that, of a series of amphibians and reptiles received by him from Andover, New Hampshire, seven out of eight "Wood" salamanders were normal red-backs, one a red mutant, and none were lead-backs.

Whereas only one or two erythristic individuals have been previously reported at one time, the present note deals with a collection of sixteen found at North Colebrook, two miles north of Colebrook, Litchfield Co., Connecticut, during August and September, 1951.

This phase closely resembles the normal red-backed phase in external characteristics and size, but differs in that the black pigment of the sides and ventrum is usually completely lacking. However, in most specimens a considerable amount of black pigment remains on the distal part of the tail. Variations range from entirely bright coral-red individuals with only a few black spots at the tip of the tail to lighter colored individuals with dark tails and many small black spots obscuring the color of the body. In most specimens there is a slight differentiation between the dorsal and lateral portions of the body and tail corresponding to the position of the dorsal stripe in the normal phase. Under the microscope the black pigment of both the normal red-backed phase and the erythristic phase appears to be arranged in a honey-comb pattern, with a large number of small, closely packed circles of black with red pigment visible at the center of each. The intensity of the black color depends upon the thickness of the lines composing this network. The red pigment, which seems to underlie the black, even in the normal striped phase, is arranged the same way on a lighter, possibly grey, background. The eyes are black in all.

All were found within a hilly area of about 2 square miles surrounding North Colebrook (altitude 1070 ft.). The region is one of abandoned farmland now overgrown with white pine (predominant) and mixed deciduous trees. The subsoil is covered with pine needles and nearly devoid of low vegetation. A swift stream (Sandy Brook) flows through the area. Rainfall and dew were abundant while I was there; nights were generally cold (5°–10°C).

Within this area 54 normal red-backed salamanders were also found, giving a ratio of normal to erythristic of about 7 to 2. None of the lead-backed phase was found anywhere in the region. Many two-lined salamanders (*Eurycea bislineata*) were also found in the same habitat, some as much as 200 meters away from the nearest permanent body of water.

All plethodons were found in or under fallen, usually rotten, birch or pine trunks lying partly buried in pine needles. Some, but no erythristic ones, were found under large stones. Two batches of eggs (5 eggs in one batch, 7 in the other), each guarded by a normal adult, were also found under logs. Although attempts to hatch these failed, all embryos seen through the egg covering seemed to be of the normal striped phase. The most interesting concentration of the erythristic phase was found on a 30° slope near Sandy Brook in a virgin white pine forest within the area. Three locations, 25 meters apart, contained five, two, and two salamanders, all of which were red. No salamanders of the normal striped phase were found with them, although some were found only a few yards away.

Aside from the North Colebrook region I covered another, 2 miles away and about 1 mile square, which differed in being slightly higher (1300–1500 ft.) and in that white pine, though present, was not dominant. Sandy Brook, with small tributary streams, flowed through this area also. Only eleven salamanders were found here, all of the normal red-backed phase.—ERIC MATTHEWS, *24 Gramercy Park South, New York 3, New York*.

THE SPADEFOOT TOAD, *SCAPHIOPUS*, IN ALBERTA.—Spadefoot toads are known to occur in a number of localities in southern Alberta, but no records for this area have been published. The first indication of the presence of *Scaphiopus* appears to be an adult taken at Medicine Hat and submitted to the University of Alberta about 1930 by F. S. Carr. No further material was collected until 1950 and 1951 when, as a result of investigations carried out by Mr. R. Lister and the writer, adults were obtained near Empress and Orion. These specimens were determined as *Scaphiopus hammondi bombifrons* (Cope), and the identification has been confirmed by Mr. E. B. S. Logier of the Royal Ontario Museum of Zoology. Additional data on the occurrence of *Scaphiopus* are provided by immature stages collected from the vicinities of Gleichen, Barons, Taber, Verdegris Coulee, and St. Kilda. Our present information indicates that spadefoot toads are widely distributed over the prairie region and constitute one of the characteristic forms of the Transition Zone in Alberta.

Adults of *S. h. bombifrons* were also collected at Alsask which is situated on the Saskatchewan side of the interprovincial boundary. Further studies would undoubtedly reveal a more extended distribution in the southern portion of that Province— J. E. MOORE, *Department of Zoology, University of Alberta, Edmonton, Alberta, Canada.*

NOTES ON SOME SALAMANDERS OF WEST CENTRAL INDIANA.—While collecting *Plethodon cinereus cinereus*, *P. glutinosus glutinosus*, and *Eurycea bislineata bislineata* for respiration and hematological studies, a number of observations on these forms were made.

A distinct difference in the relative numbers of the two color phases of *P. c. cinereus* has been noted by workers in various geographic locations. Lynn and Dent (1941, COPEIA (2): 113–14) reported that 71 percent of 166 specimens collected in the vicinity of Baltimore, Maryland were of the gray phase, whereas at Woods Hole, only 14 percent of 84 specimens were similarly characterized. In Indiana, Blatchley (1891, Jour. Cincinnati Soc. Nat. Hist., 14: 22–35) reported that in Vigo County both color phases are equally represented. Grant (1936, Proc. Indiana Acad. Sci., 45: 323–33) found that in northern Indiana 70 per cent of the members of this species are of the dark color phase. In Putnam County, Indiana, Reynolds and Black (1936, *ibid.*, 45: 287–94) noted that 5.6 percent of 125 specimens were of the gray phase. However in Ann Arbor, Michigan, Blanchard (1928, Amer. Nat., 62: 156–64) was unable to find evidence that the two phases were distributed unequally. In the present study it was found that 59 of 117 (50.4 percent) specimens collected in Tippecanoe and Parke counties, Indiana, were of the dark phase.

Measurements of 44 adults of *P. c. cinereus* disclosed that the average overall length was 73.1 mm.; the largest being 109 mm. The average body length, measured from the tip of the snout to the posterior part of the hind leg at the junction with the body, was 40.3 mm.; the average tail length was 32.8 mm.

Plethodon cinereus cinereus is very abundant in these two counties. Collection records indicate that the relative abundance of the four most common forms is as follows, in descending order: *P. c. cinereus*, *E. b. bislineata*, *P. g. glutinosus*, and *P. c. dorsalis*. It should be noted that few specimens of *P. g. glutinosus* have been collected in Tippecanoe County; this form appears to be the most restricted species in its habitat preference, whereas, *P. c. cinereus* is the least. It is not uncommon to find the red-backed salamander under the same log or rock along with one or more of the other forms. *E. b. bislineata* is usually found in a semi-aquatic habitat.

In addition to the four species previously mentioned, the following salamanders have been collected by the author in these two counties: *Ambystoma maculatum*, *A. tigrinum tigrinum*, *Eurycea longicauda longicauda*, and *Hemidactylium scutatum*. *Necturus maculosus maculosus* and *Eurycea lucifuga* have also been reported from these counties.— F. JOHN VERNBERG, *Department of Zoology, Duke University, Durham, North Carolina.*

ATRACTASPIS (MOLEVIPER), A NEW RECORD FOR EGYPT.—A specimen of the moleviper, *Atractaspis engaddensis* Haas, recently described from Palestine, was collected in Egypt by Mr. Harry Hoogstraal during 1950. This is the first and only specimen of any species of the genus recorded from Egypt (Flower, 1933, Proc. Zool. Soc. London: 735–851; and Laurent, 1950, Mem. Inst. Roy. Sci. Nat. Belg., 38: 3–49), and it also extends the range about 200 miles, airline, to the southwest; the species was previously known only from the type locality near the Dead Sea (Haas, 1950, COPEIA (1): 52, fig. 1).

The specimen is now in the Chicago Natural History Museum herpetological collection (CNHM 63112). This specimen (in bad condition), a male, was collected in the Feiran Oasis (= Wadi Firan or Feran), Sinai Governorate, Egypt, July 28, 1950. The sex of the type, and of the paratype, is not given in the original description. The specimen agrees closely with the original description and is similar to the illustration of the paratype. Differences noted between the original description and the Sinai specimen are as follows:

Character	Paratype	Type	CNHM 63112
Ventrals	264	277	281
Subcaudals	36	39	36
Temporals	2–3	2–4	3–3 left 3–4 right
Internasal suture / Interprefrontal suture	"Nearly equal"	...	$\frac{1}{3}$
Scales between chin-shields and first ventral	11	...	13
Total length	"Twice that of type"	650 mm.	414 mm.
Tail lengtn	"Twice that of type"	60 mm.	28 mm.

The lower anterior temporal is very large in the paratype (description and illustration), whereas in the Sinai specimen the lowest anterior temporal is small.—HYMEN MARX, *Chicago Natural History Museum, Chicago, Illinois.*

OBSERVATION ON THE FEEDING HABITS OF THE BLACKSNAKE, *COLUBER CONSTRICTOR CONSTRICTOR*.—It is common knowledge that the common blacksnake, *Coluber constrictor constrictor* Linnaeus, and others of the same genus survive poorly in captivity. The snake's extremely irritable disposition prevents proper feeding and its constant striking causes injury to itself often resulting in death.

In August, 1951, this writer had collected a number of specimens for observation. These snakes, several dozen natricines of various species, two specimens of *Thamnophis sirtalis sackeni*, and two *Coluber c. constrictor*, were all put into a single container which was kept inside a building in a relatively dark place. Early one morning the container was removed to a place where there was considerable artificial light and the covering was removed. None of the specimens had been fed since their capture although a pan of water had been provided. The blacksnakes and the ribbonsnakes had been caught about the same time in the same general area and had been together in captivity for about a week.

As soon as exposed to light the ribbonsnakes darted rapidly about the cage and the blacksnakes assumed their characteristic striking poise. As one of the ribbonsnakes, about 18 inches in length, started to crawl rapidly past a poised blacksnake, 30 inches in length, the latter quickly struck it in the middle of the body and did not release its hold despite the vigorous efforts of the victim to escape. The blacksnake began a chewing, grinding motion, as though it were attempting to imbed its teeth deeply. After approximately two minutes of this "chewing" the ribbonsnake ceased to struggle, but the chewing motion was continued at the same place on the body for a full five minutes; then the blacksnake started moving his mouth over the victim's body until the head was reached. Swallowing was completed in an additional five minutes. At no time after the strike did the blacksnake release its hold. The manner by which the blacksnake reached the victim's head reminded this writer of the characteristic way that *Natrix* maneuvers a fish.

Although several people observed the entire procedure, the feeding snake was apparently oblivious to their presence.—IST LT. JON H. HULME, USAFR *c/o Simpson, Star Route, Mary Esther, Florida.*

ON SNAIL-EATING SNAKES.—In his interesting paper on the snail-eating snake genera *Dipsas* and *Sibon*, Dr. E. R. Dunn (1951, Evolution 5: 355–8) implies that he is unaware of any published observations of the actual process of feeding. Several such observations have been made for terrarium specimens in Germany. I have been able to watch a juvenile *Dipsas albifrons* anchor its teeth firmly by striking into the slippery body, close to the shell, of *Cepaea nemoralis*. It then extracted the body from the shell without difficulty by peculiar chewing movements of the jaws, in the surprisingly short time of 1 to 2 minutes. Rembold (1934, Bl. Aquar. Terr. Kunde, 45: 386) observed the snail-eating process in the same species. This procedure has been described more exactly by Lankes (1930, *Ibid*. 41: 300) for *Dipsas variegata*. After eating a snail, the snake invariably rubbed each side of its head on the trunk of a tree several times, as I can confirm from my own observations; this is done, evidently, to remove the sticky mucus, though Lankes writes of a "massage" of the jaws. The snake then opens its jaws as if yawning, presumably to bring the jaws into place.

There is still another snake that feeds on snails, at least as a juvenile, namely, *Tomodon dorsatus*. In this snake the last two teeth of the very short and movable upper jaw are unusually long, so that they accomplish, presumably, a secure hold of the slippery prey (Ernst, 1951, Aquar. Terr. Zeitschr., 4: 246).—ROBERT MERTENS, *Senckenbergische Naturforschende Gesellschaft, Frankfurt a. M., Germany.*

A MAINE RECORD FOR BLANDING'S TURTLE.—A large male specimen of Blanding's Turtle, *Emys blandingi* (Holbrook), was taken June 30, 1950, in Hampden Highlands, Penobscot County, Maine. The collector was a boy, James Parsons, of that town. I saw him within an hour of the capture and learned that he had found the turtle walking along a road just off U. S. Route 1 which runs

through Hampden Highlands at a distance of about ¼ mile from the west bank of the Penobscot River. On the day of its capture the turtle served as an exhibit in a summer vacation school held at the local church. Then the turtle was taken to Parsons' home, where a hole was bored in one of the marginal plates for the attachment of a wire. In addition to this hole there is, on the right side of the 3rd vertebral shield, what appears to be a crudely executed "K," which antedates its capture by Parsons. A day or two later, realizing that it was an unusual species for Maine, I persuaded young Parsons to turn the turtle over to me to be deposited in the University of Maine Zoology Department collection. At that time the live weight of the turtle was 2 lbs., 14 ozs.; the carapace length was 9 inches. The turtle was killed and preserved July 3, 1950. As nearly as I have been able to determine, this is probably a first record of the occurrence of Blanding's Turtle in Maine.—ALBERT A. BARDEN, JR., *Department of Zoology, University of Maine, Orono, Maine.*

TOWARD REDUCING COST IN MAILING REPTILES.—During the past two years I have been receiving spirits specimens mailed by Mr. John C. Williams of the Coryndon Museum, Nairobi, Kenya Colony, in an altogether satisfactory, transparent, flexible plastic. This material comes in an endless tube about nine inches in width. After cutting off a length suitable to the number and size of specimens to be packed, a knot is tied in one end and the resulting bag is turned inside out so that the knot is on the inside. After packing the specimens, preferably wrapped in spirit-soaked cotton cloths, into the bag, the open end is gathered together and either knotted, if there is sufficient slack, or securely tied with string. To make doubly sure that the container is sealed, the end can be turned over and bound again, or, if desired, the bag can be slipped inside another section for additional protection. The package should then be placed in a carton, box or can, watertight or not, for shipment.

Mr. Williams informs me that the material is also useful for protecting cameras or other goods from exposure to tropical dampness. It is called "Plax Polyethylene Layflat Tubing," and is supplied, in large quantities only, by the Plax Corporation Division, Hartford-Empire Co., P. O. Box 1019, Hartford 1, Connecticut. Most Woolworth stores carry polyethylene bags in a wide range of sizes, though not in such heavy material as one could wish, and these are even simpler for shipping small numbers of specimens.—ARTHUR LOVERIDGE, *Museum of Comparative Zoology, Cambridge 38, Massachusetts.*

LONGEVITY OF SNAKES IN CAPTIVITY IN THE UNITED STATES.—This list contains what records are available to us. We would like to hear from anyone having better records, or ten-year records of other species. We intend to bring the list up to date each year as of the first of January. Only the oldest snake of each species or subspecies is listed. Age is given in years (second column) and months (third column), and the source of the record is included (fourth column). An asterisk indicates that the specimen was alive on January 1, 1952. Symbols used are as follows: AM = American Museum of Natural History, BdZ = Brookfield Zoo, BxZ = Bronx Zoo, GOW = Grace O. Wiley, GPM = George P. Meade, NCM = North Carolina State Museum, PZ = Philadelphia Zoo, RMS = R. M. Stabler, RR = Robert Riggs, SDZ = San Diego Zoo, SIZ = Staten Island Zoo, SLZ = St. Louis Zoo, TC = Tabor College, WZ = Washington Zoo.

*Agkistrodon contortrix laticinctus**	11	7	SDZ
*Agkistrodon contortrix mokeson**	15	6	SDZ
*Agkistrodon piscivorus**	16	8	RMS
Boa annulata	12	4	PZ
*Boa enydris cooki**	12	8	SDZ
Boiga dendrophila	11	9	SLZ
Constrictor constrictor constrictor	12	3	PZ
*Constrictor constrictor imperator**	14	3	SDZ
Crotalus adamanteus	14	9	NCM
*Crotalus atrox**	15	7	SDZ
Crotalus basiliscus basiliscus	10	1	SDZ
*Crotalus unicolor**	11	5	SDZ
*Crotalus horridus horridus**	14	7	SDZ
Crotalus mitchelli pyrrhus	11	9	SDZ
Crotalus ruber ruber	12	3	SDZ
*Crotalus tortugensis**	14	9	SDZ
*Crotalus viridis helleri**	14	10	SDZ
*Crotalus viridis viridis**	13	1	SDZ
Drymarchon corais couperi	12	11	RR
Dendroaspis viridis	11	3	SLZ
Elaphe guttata guttata	21	9	PZ
*Elaphe obsoleta confinis**	10	5	RMS
*Elaphe obsoleta obsoleta**	14	6	AM
*Elaphe obsoleta quadrivittata**	14	7	SDZ
*Epicrates angulifer**	13	2	SDZ
*Epicrates cenchria crassus**	14	2	SIZ
Epicrates cenchria maurus	27	4	BxZ
Epicrates striatus	16	0	PZ
Eunectes barbouri	13	11	PZ
Eunectes deschauenseei	13	10	PZ
Eunectes murina	28	0	WZ
Helicops schistosus	12	3	PZ
*Hemachatus haemachatus**	10	6	BdZ
*Lampropeltis doliata amaura**	15	7	GPM
*Lampropeltis doliata annulata**	11	5	SDZ
Lampropeltis getulus brooksi	10	0	SDZ
Lampropeltis getulus californiae	14	10	SDZ
*Lampropeltis zonata multicincta**	12	4	SDZ
Lichanura roseofusca roseofusca	12	0	SDZ
Masticophis flagellum piceus (black)	11	2	SDZ
Masticophis flagellum piceus (red)	12	2	SDZ
Masticophis flagellum testaceus	13	5	SDZ
*Naja melanoleuca**	23	3	SDZ
Naja naja	12	4	PZ
Naja naja atra	10	3	BdZ
*Naja nigricollis**	17	2	BdZ
*Naja nivea**	14	11	SDZ
Ophiophagus hannah	11	10	GOW

*Pituophis catenifer affinis**	11	8	SDZ
Pituophis catenifer annectens	15	2	SDZ
Pituophis catenifer catenifer	11	0	SDZ
*Pituophis melanoleucus melanoleucus**	11	5	SDZ
Python curtus curtus	17	5	SLZ
*Python molurus bivittatus**	15	7	SDZ
Python molurus molurus	13	0	PZ
Python reticulatus	20	0	SLZ
*Python sebae**	15	1	PZ
*Rhinocheilus lecontei lecontei**	10	1	SDZ
Sistrurus catenatus	14	0	TC
Ungaliophis guatemalensis	17	8	GOW

—C. B. PERKINS, *Zoological Society of San Diego, San Diego, California.*

PRELIMINARY NOTES ON THE GIANT TOAD, *BUFO MARINUS* (LINN.), IN THE PHILIPPINE ISLANDS.—The neotropical giant toad is at present a locally abundant species in some parts of the Philippines. It is found in coastal areas of Negros and the nearby islands of Panay and Guimaras, on Luzon in the towns bordering Laguna de Bay and in the Central Provinces of Bulacan, Pampanga and Tarlac, and in scattered parts of Mindanao.

In March, 1934, Dr. Gonzalo Merino of the Philippine Bureau of Plant Industry brought to Manila from Hawaii, about 50 giant toads which he secured from the Hawaiian Sugar Planters Association. Dr. Merino's decision to introduce *B. marinus* to the Philippines was based on a thorough investigation on its effectiveness as an insect predator in Hawaii. The records on the introduction and subsequent release of *Bufo marinus* in the Philippines were burned during the liberation of Manila. Dr. Merino reconstructed from memory the data pertaining to the Luzon and first Negros introductions. I am indebted to him for this information.

Several interesting questions may be answered by a study of *Bufo marinus* in the Philippines: (1) the length of time this species requires to establish permanent breeding populations in new areas; (2) the rate of spread; and (3) its effects on the fauna of a new area.

The toads were reared at first in the compound of the Bureau of Plant Industry in Manila. Later, some of them were transferred to Los Banos, Laguna Province, in the grounds of the College of Agriculture of the University of the Philippines, from which some escaped. Several years later *B. marinus* was found in great numbers in the locality. Toads were deliberately released in Calauang and Pila, Laguna Province, and in the Central Luzon provinces. Prior to 1941, the species was not so abundant in Central Luzon as in the Laguna area. In 1935–36, *B. marinus* was released in sugar plantations of northwestern and western Negros Island. In 1939–40, some were brought to Silliman University and released in Dumaguete and environs. By 1945, these toads occurred in immense numbers everywhere in Dumaguete City and nearby villages. They have even begun to invade the foothills and the neighboring towns in the southeastern part of Negros. It is now reported as far southwest as Santa Catalina. Between 1936 and 1939, *B. marinus* was introduced into Guimaras and Panay Islands. In 1949, the Biology Department of Silliman University sent by request about thirty specimens to Midsayap, Cotabato Province, Mindanao. Subsequently, additional toads from Dumaguete City were introduced by farmers into Zamboanga and Davao Provinces, Mindanao.

It is apparent from the foregoing that *B. marinus* has required only five or six years to establish breeding populations in several parts of Negros. At night these toads are the commonest vertebrates seen anywhere in Dumaguete City and nearby localities. Their dead bodies litter the roads where they are crushed by vehicles.

Thus in the short span of fifteen years (1934–49) *B. marinus* has spread from Manila to southern Mindanao. Although its dispersal from island to island and most of its movements from one part of an island to another have been accomplished by the deliberate action of man, it has spread throughout the countryside within a radius of 20 kilometers of Dumaguete City on its own powers.

Although Negros Island does not have any endemic species of *Bufo*, there are fourteen native forms of amphibians. The most common native species in the neighborhood of Dumaguete City are *Rana erythraea* (Schlegel), *R. cancrivora* Gravenhorst, *Oxyglossus laevis* Günther and *Kaloula conjuncta* (Peters). *R. erythraea* is most abundant along streams but is occasionally found in ponds. *R. cancrivora* and *O. laevis* are characteristic inhabitants of flooded fields, marshes and ditches. *K. conjuncta* is terrestrial and is often found under dead leaves and other detritus. The three aquatic species breed in the habitats noted; *Kaloula* breeds in shallow pools of standing water.

Around Dumaguete City *B. marinus* is present in large numbers along streams, in meadows and cultivated fields, under coconut groves and bamboo thickets. During the day the toads hide under dead leaves and other debris, inside clumps of grass and bushes, under weeds, at the sides of ditches, under the large clods in plowed fields, and, generally, in any dark retreat. They are even found under and inside houses. *Bufo marinus* breeds in all of the aquatic sites mentioned in connection with the native species.

Prior to the introduction of the giant toad in Dumaguete City, the four native species were commonly observed at night on trips designed to collect *R. erythraea* and *R. cancrivora* for laboratory

use in Silliman University. Now, however, in the same localities only occasional specimens are encountered although *B. marinus* is seen in great abundance; the native species retain their former abundance only in the interior of Negros where *B. marinus* has not penetrated. During the breeding season, in September and October, the strings of *Bufo* eggs are found in tremendous numbers in all the breeding sites used by the native forms. The native species still utilize these sites but their spawn is much less abundant than that of *B. marinus*. As yet the processes by which *B. marinus* is driving out the native species are unknown.

Since 1945 the zoology classes of Silliman University have been using *B. marinus* as a laboratory animal. As many as three to four thousand specimens are used every year. During the course of these classes cursory examinations of stomach contents have indicated that insects form the main bulk of the food. Of approximately 5,000 stomachs examined, 17 contained remnants of the small burrowing snake, *Typhlops*. Two live individuals of the genus *Typhlops* were regurgitated by newly captured *B. marinus*. Rat fur, probably of the common field rat, *Rattus rattus mindanensis* Mearns, was found in two stomachs. Professor E. T. Gervacio of Silliman University reports that he has seen large toads attack weak chicks. Until a detailed analysis of feeding habits is made, the effects of *B. marinus* on the fauna will remain uncertain.

Bufo marinus may have indirect effects on parts of the fauna of the Philippines. There is at present a great decrease in the cat population of Dumaguete City because of poisoning resulting from cats playing with toads. The cats do not always die but may suffer from extreme emaciation for several weeks. The effect on this domesticated predator naturally has repercussions on the populations of their normal prey.

There is one case of fatal poisoning suffered by man. In 1941, the Chief of Detectives of a municipality of Iloilo Province, Panay, died after a meal of 3 toads. These were mistaken for edible frogs. The uneaten remainder was sent to the Division of Fisheries, Manila, and was identified by myself as *Bufo marinus*.

Professor E. T. Gervacio is at present engaged in experimentation on the possibilities of using the dried meat of the giant toad as poultry feed, after of course removing the parotoids and the skin. If this project is successful, a means will have been found to help control the rapid increase in numbers of this introduced species.

A more detailed study of the biology of this giant toad is to be undertaken.—DIOSCORO S. RABOR, *Silliman University, Dumaguete City, Negros Oriental, Philippine Islands.*

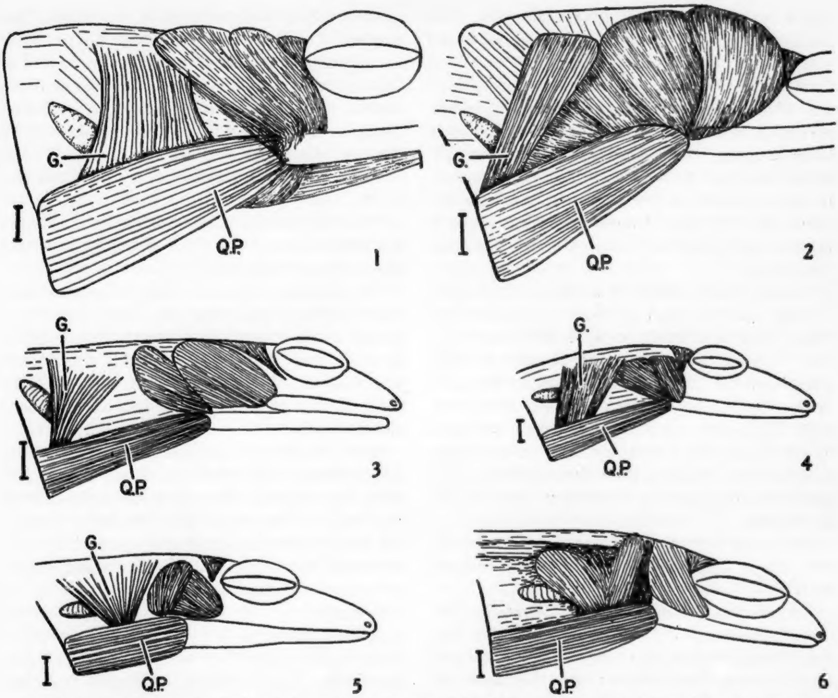
THE GULARIS MUSCLE IN *ANEIDES* AND *HYDROMANTES*.—Smith (1920, Jour. Morph., 33: 527–51) was the first to apply the name "gularis" to a muscle found in the throat region of adult *Eurycea*. Piatt (1935, *Ibid.*, 54: 213–51) extended this to many plethodontids. Eaton (1937, *Ibid.*, 60: 317–24) suggested the name gularis for muscle in the region of the so-called interhyoideus posterior or quadrato-pectoralis.

For the present at least, I prefer the terminology of Piatt and consider the quadrato-pectoralis as a separate part which is connected with the region of the angle of the jaw and the quadrate. The gularis does not have these connections but originates from fascia on the side of the body and is inserted into the nuchal line or fold.

Piatt called attention to the large functional quadrato-pectoralis in *Aneides lugubris*, with a smaller but distinct gularis running *under*, not over it, a marked difference from the other plethodonts. I have confirmed this condition in *A. lugubris*. I also found the gularis under the quadrato-pectoralis in *A. aeneus*, *A. flavipunctatus*, *A. ferreus* and in *A.* (*Plethodon*) *hardi* (Figs. 1–6).

I have examined salamanders of most genera of the Plethodontidae and have found no other indication of this condition except in *Hydromantes platycephalus*. Here, a muscle somewhat like the gularis in *Aneides* seems to be present. It runs under the quadrato-pectoralis but is farther forward than in any of the other species. Such a position for the gularis is not described by Piatt in *H. genei*, nor did I find it in the one specimen examined. This muscle in *H. platycephalus* has quite an extensive origin. Because of its forward position, appearing almost like the so-called anterior interhyoid, it may not be entirely homologous with the gularis in the other species.

The extent of the quadrato-pectoralis and the gularis in various forms is as follows: *A. aeneus*: length of the head to gular fold 13 mm.; Q.P. 4 mm. long by 3.5 mm. wide; G. 4 mm. long by 4 mm. wide. *A. flavipunctatus*: length of the head to the gular fold 12 mm.; Q.P. 5 mm. long by 2–3 mm. wide; G. 3.5 mm. at widest. *A. ferreus*: length to gular fold 13 mm. (I am not sure of the identity of this specimen; it is an *Aneides* but may not be *ferreus*); Q.P. 8 mm. by 4 mm.; G. 2 mm. by 3 mm. *A. lugubris*: length to gular fold 14 mm.; Q.P. 6 mm. by 4–5 mm.; G. 4 mm. by 4 mm. *A.* (*Plethodon*) *hardi*: length to gular fold 11 mm.; Q.P. 4 mm. by 2 mm.; G. widest 4 mm. *Hydromantes platycephalus*: length to gular fold 11 mm.; Q.P. 6 mm. by 2 mm.;



Figs. 1-6. Quadrato-pectoralis and gularis muscles in *Aneides* and *Hydromantes*. Fig. 1, *A. lugubris*. Fig. 2, *A. ferreus* (?). Fig. 3, *A. flavipunctatus*. Fig. 4, *A. hardi*. Fig. 5, *A. aeneus*. Fig. 6, *H. platycephalus*. Scale equals 1 mm.; Q.P.; Quadrato-pectoralis; G., Gulgaris.

G. 3 mm. by 4 mm.—William A. Hilton, *Pomona College, Claremont, California.*

HERPETOLOGICAL NOTES FROM NORTHEASTERN BRAZIL.—I had several opportunities for field work in the states of Bahia and Pernambuco, when stationed there with the United States Navy from August, 1943 to March, 1944. In January, 1944, I was able to spend several days in the interior of Pernambuco, about 180 kilometers inland, at Garanhuns, altitude 880 meters.

I was unable to find extensive, local collections of preserved specimens in this region. In Recife, at the Escol Superior do Agricultura, there is a collection of about 100 specimens. Here also is a small antivenin institute where the "Cascavel," *Crotalus terrificus* (Laurenti), and the "Surucucu," *Lachesis muta* (Linnaeus) were on hand. There is also a small collection at the Collegio Pernambucana. The curators were very friendly.

Annotated List of Species: *Tropidurus torquatus hispidus* (Spix). "Lagartixa."—This, the most common species of lizard in Bahia and Pernambuco; it abounds in and out of houses, out in the countryside, and into the interior as far as I went. These lizards are lively, curious, fairly easily caught by hand or snare, and are frequently seen chasing each other. They escape by dodging and running, or by hiding in holes in the ground or under bark. I saw them frequently scratching around in humus and earth, sometimes digging holes two inches deep, using their forefeet one or both at a time. On February 24, I observed one pair mating about ten feet from the ground on a rough stucco wall. Both individuals were holding to the wall, the male higher than the female. The male, which was about two-thirds larger than the female, had his left hind leg thrown over her and their genital orifices were in apposition. In general appearance and behavior, this species resembles *Sceloporus* in North America.

Platynoia semitaeniatus (Spix).—One specimen was caught about 2 or 3 kilometers south of San Caetana, Pernambuco, near the highway to Garanhuns. In the scrubby arid brush this species also closely resembled *Sceloporus*. The specimen that I secured ran away fast, with the body held high, for about 40 feet, and dodged under a flat rock. It's color in life was brown-black dorsally, gray ventrally, with reticulated gular area and some black

scales under thighs and in the preanal area. Most distinguishing feature is a light yellow-green dorsal stripe (about 4 scales, or 2 mm., wide) extending from the fronto-nasals onto the tail where it fades out. There is some light color along the upper jaw extending to the fore limb. There is also a series of irregular spots forming rough barring on either side of the head and the arms dorsally. Ventral surface is cream. (In alcohol the light dorsal markings become greenish-cream.) A rather concentrated search for more specimens in this and other similar areas was fruitless.

Ameiva ameiva ameiva (Linnaeus). "Calonga."—Quite common about Bahia at the Yacht Club where there is a brushy rocky hillside above the bay. They are too fast and alert to catch by hand unless cornered in one of their holes. In this area earth tunnels abounded, most of them in the rock cliffs. The natives assert that the tunnels are made by the lizards, but I could not verify this. On one occasion a cat caught a good sized specimen. This species was also observed in the deep jungle in the Recife area.

The young show green only on the head and shoulders, but in large adults the entire body and tail are likewise a verdant green.

Cnemidophorus ocellifer (Spix). "Vebra"; "Calonga."—I secured two specimens on the dry flats near Olinda, Pernambuco. Here the natives call them "Calonga," not differentiating them from the larger *Ameiva*. On an expedition into the interior of Pernambuco, only smaller individuals were observed, called "Vebra" by the natives. They were common in many parts of the arid country and cultivated fields at Caruaru, Garanhuns, and intermediate points. They are spry and alert, escape by dashes of speed, and occasionally hide under rocks, logs, etc. I found them very difficult to catch.

The two dorsal stripes on either side, prominent in the younger individuals, fade in the older ones; an azure coloration on the head and flanks was quite prominent in the adults I secured. There is also a brick-red mottling on some of the ventral scales in the adults.

Mabuya mabouya mabouya Lacépède.—I could find no native name other than the general "Lagartixa." They were found in largest numbers about Garanhuns, Pernambuco, and were also secured at Olinda. On one moderately cloudy day we found them to abound in the cotton and corn fields. One juvenile was found asleep on a clod of earth along the trail. Generally they were caught only after concentrated attack around brush and stones and earth clods.

The adult showed a lessening of distinctness of the stripes; none other than dull gray or brown base coloration was noted.

Hemidactylus mabouia Moreau de Jonnes.—Only one individual was observed. This was, oddly enough, on the seventh floor of the Edificia Oceania, Bahia, a most modern apartment house. It was secured at night in a hall that is nearly always darkened. It tried to bite when caught and appeared blinded by light.

Rana palmipes Spix.—Quite common about Recife, particularly around the ponds at the zoological park. They hide in deep grass, from the water's edge to 3 or 4 feet back. They are rather sluggish but make up for this by their hiding and the suddenness of their jumps. Individuals "play possum" to a surprising degree.

Hemipipa carvalhoi Miranda Ribeiro.—A series of adults, juveniles, and tadpoles was obtained about 5 miles west of Garanhuns in sink holes of an old stream. There, the natives dipped them out with wicker baskets. During the heat of the day they were all deep in the mud and under the matted surface growth. Natives say they go two feet into the mud during dry spells when the ponds dry up.

In addition to the above, the following species were collected for me at Salinas, Bahia: *Bothrops jararaca* (Wied), *Ophis severus* (Linnaeus), *Chlorosoma aestivum* (Duméril and Bibron), *Bufo marinus* (Linnaeus), *Leptodactylus pentadactylus* (Laurenti) and *Leptodactylus ocellatus* (*Linnaeus*).

The majority of these specimens are in the United States National Museum.—MURRAY L. JOHNSON, M.D., *Puget Sound Museum of Natural History, College of Puget Sound, Tacoma, Washington.*

REVIEWS AND COMMENTS

LIFE IN LAKES AND RIVERS. By T. T. Macan and E. B. Worthington. Collins, 14 St. James's Place, London, 1951: xvi + 272, 20 figs., 72 pls. (40 in color). 21s ($2.92).—As part of a survey of British natural history, this book takes its rightful place among the other outstanding contributions in the *New Naturalist* series. With a refreshing approach, the authors carry the reader in easy

stages through 16 chapters that cover the biology of lakes and rivers and the methods used in studying these waters. The book is entirely ecological in outlook but without the encumbering ecological terminology of some works that wilts the readers' interest. Although not written primarily for specialists, the volume abounds in material of great interest to all students of aquatic biology. The authors have effectively overcome a difficulty in a book of this nature—to leave the reader with a good impression of what is not known. Chapters 7, 8, and 9, dealing with the organism in its environment and food chains and productivity, and chapters 12 and 13, covering size, maturity, and growth in fishes, are particularly informative. Fish cultural practices in this country come in for a just amount of criticism.

The 40 magnificent color plates, sparklingly clear, are alone worth the price of the book. The halftones are also outstanding, and the text matches the illustrations in excellence. This book is highly recommended not only for limnologists and their students (as a fine introductory text), but to all those who have an interest in inland waters. The authors and the publisher are to be congratulated on producing a book of such high quality at so reasonable a price—goals which American writers and publishers would do well to emulate.—ROBERT RUSH MILLER, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

LIMNOLOGY. By Paul S. Welch. Second Edition. McGraw-Hill Book Company, New York, 1952: 538 pp., 50 figs. $8.00.—Biologists familiar with the first edition of this well-known text book will find themselves thoroughly at home in paging through this recent revision. Little of the material of the first edition has been sacrificed or revised. New material, together with an expanded bibliography has added 67 pages to the volume. Additions from the extensive literature of the past 16 years are incorporated entirely within the original outline. Several new tables and figures have been added, but the major portion of the illustrative material of the first edition has been retained.

It is disappointing to find that a more generous revision of this valuable text has not been possible. Running waters and ponds, topics worthy of considerable expansion, have received only modest additions. The chapter dealing with the limnological relationships of fish and other free-swimming forms attempts to do little more than outline the spatial distribution of these forms within the aquatic community. Only brief attention is given to topics of recent and applied interest such as impounded waters, artificial fertilization and the influence of pollutants.—FRANK F. HOOPER, *Institute for Fisheries Research, University Museums Annex, Ann Arbor, Michigan.*

AN INTRODUCTION TO THE STUDY OF THE ETHOLOGY OF CICHLID FISHES. By G. P. Baerends and J. M. Baerends-Van Roon. Behaviour, Supplement I; E. J. Brill, Leiden, Netherlands, 1950: vii + 243 pp., 60 figs. 15 florins ($4.00).—The authors point out that: "The aim of this paper is to give a survey of the behaviour of the Cichlid fishes based on aquarium observations and to raise problems for further research." This aim seems to have been accomplished with amazing success.

The volume is divided into eight chapters. Chapter one is a description of the anatomy of the locomotor system. In chapter two the authors describe the elementary actions in relation to coordinated muscle contractions. These are divided into coordinated locomotory movements, reactions that apparently serve to make the fish feel more comfortable, movements relating to the environment but not serving as signals to other fishes, and signal movements—with further subdivisions of these four primary types. Chapter three deals with the mechanism of the jaw and gill apparatus (inhalation, exhalation, and display). Chapter four presents in detail the color and pattern of eight species of cichlids (genera *Cichlasoma*, *Hemichromis*, *Haplochromis*, and *Tilapia*). Color and pattern, along with behavior patterns, serve as a primary distinction between species and as an isolating mechanism. Artificial hybridization, if successful, should prove interesting. It would reveal to what degree physiological (genetical) isolating mechanisms are developed and also whether or not this type of information can be used to determine phylogenetic relationships.

Chapter five is concerned with social organization and territorialism. Schooling is discussed as is the type, establishment, maintenance, and function of territories. Some of the discussion in this chapter apparently lacks insight and completeness because the authors seem to be looking for a common cause and effect. Also, because the investigations were halted in 1943, some recent papers of importance are not included. There are only two literature citations after 1943. Another reason for the weaknesses in this chapter is that we know very little of the occurrence and of the types of territories to be found in most groups of vertebrates, especially fishes.

Chapter six contains a description of pair formation in the two major types of parental care, the non-oral and the oral incubators. Chapter seven deals with the care of the offspring. Recognition of eggs and young, reactions of the young to the parents, and reactions of the young to each other are

examined in detail. In chapter eight an attempt was made to fit the observed behavior of the cichlids into Tinbergen's four types of signal movements of animal language, namely, displacement reactions, awakening movements, preparatory movements, and demonstration movements (the hierarchical system of the European behavorists).

Although this book contains the most complete study of behavior on any group of fishes to date, several adverse criticisms should be mentioned. In general, the reader has no knowledge of the number of observations each description of the behavior elements is based upon. Secondly, aquarium studies may lead to gross error in the interpretation of the functions of various elements of behavior because of abnormalities not present in the natural environment. The reviewer has found this to be true in aquarium studies of the darters of North America. Very little is known of the behavior of cichlids in their native habitats. Interpretation of territories is especially dangerous in this respect. One type of analysis that no one seems to have attempted is a study of the minimum and maximum sizes of territories, using graded sizes of tanks and a variable number of adults (the space and competitive factors). Animal behavior of the type presented by the authors has not advanced to a point where enough experiments have been tried on one particular aspect of behavior so that it can be adequately tested statistically. More general surveys like this study on the cichlids are needed first. The authors realize the above difficulties with acute awareness throughout the text. In the introduction they state: "Originally it was not intended to publish the knowledge gained before more detailed investigations had been carried out. However after the observations and experiments had been carried on for about a year, the work had to be stopped as a result of war circumstances. As then it was very doubtful that the present authors should ever take up this work again, they thought it better to publish it, incomplete as it is."

Students of the behavior, ecology, and systematics of fishes and other vertebrates should hail this monumental work as a goal to strive toward. Investigations of this type are at a very low ebb in America today. As a result the field lacks a healthy exchange of ideas and a rapid evolution of the tentative ideas developed by such European behavorists as K. Lorenz and N. Tinbergen.—HOWARD ELLIOTT WINN, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

A COLORED ATLAS OF SOME VERTEBRATES FROM CEYLON. Vol. 1, Fishes. By P. E. P. Deraniyagala. Ceylon National Museums, Colombo, Ceylon, 1952; oblong, 25 x 32 cm.; xii + 147 pp., 1 plain and 34 colored pls., 60 text-figs.—In 1949 Mr. Deraniyagala issued "Some Vertebrate Animals of Ceylon," as volume one of "The National Museums of Ceylon Pictorial Series." That book contained a smattering of all Ceylon vertebrates, and to the reviewer's knowledge, no volume two has appeared. Now, however, we have volume one of a more ambitious and comprehensive work, giving descriptions and colored or black-and-white figures of Ceylonese animals. The text and text-figures are drawn mostly from the author's published papers and the coverage of Ceylon fish species is complete only for groups specialized in by him.

It is useful to have all this information under one cover, and good colored plates are a real help to the ichthyologist. However, the great cost of the latter and the obvious need for more basic revisions of marine foodfish groups in Ceylon make one wonder if expensive picture-books are as worthwhile as other work that might be published, even granting the comparative cheapness of printing in Asia. Nor can the reviewer see good reason for presenting such huge figures of very small fishes when there are no special features demanding such great enlargement.

On the technical side we may point out some editorial carelessness regarding the eel species whose teeth are diagrammed in Fig. 31. Seldom has such confusion been seen when one follows through the text on eels trying to trace references to this figure. Moreover, the morays are headed *Gymnothorax*, keyed as *Lycodontis*, and referred to specifically as *Gymnothorax* again. The treatment as subspecies of the two forms of *Coryphaena*, which are sympatric, circumtropical species, is justified by no theory or practice of systematics known to the reviewer, and the author's remarks under *Channa* suggest that he misunderstands the biological situation indicated in regard to *C. orientalis* and *Ophicephalus gachua* by Myers and Shapovalov in 1931. The reviewer questions the value, the need and the ethics of naming subspecies (as with *Anabas* on p. 111) without adequate study of the supposedly related subspecies. No real knowledge is contributed by such naming, and the labor of working out the true situation is cast upon the shoulders of later investigators. Yet many zoologists, including some in the United States, still name not only subspecies but even species in this offhand way. Finally, the bibliography and the zoogeographical remarks, although perhaps adequate for a picture book designed solely for distribution in Ceylon, are all too brief.

Despite technical criticism, however, we wish to congratulate the author on the publication of perhaps the most important and useful single work on Ceylon fishes that has ever appeared.—GEORGE S. MYERS, *Natural History Museum, Stanford University, California.*

EXPERIMENTAL STUDY OF MERISTIC CHARACTERS IN FISHES. By Å. Vedel Tåning. Biol. Rev., 27: 169–93, figs. 1–10. 1952.—Systematic ichthyologists rely heavily upon meristic characters in describing the lower taxonomic and unnamed units, from the population through the species. The influence of the various environmental factors on variation has, however, been investigated only to a very small extent by means of experimental studies. Up to now practically nothing has been known of the time or stage when meristic characters are determined in early ontogeny or of when characters can be changed by altering one or several of the environmental factors. Information on these matters comes almost entirely from experiments on *Salmo t. trutta*. A specially sensitive period for the determination of vertebrae in sea trout lies between about 145 and 165 day degrees—shortly before the "eyed-egg" stage. During this period a relatively moderate change of temperature (3–6°C.) can produce an average difference of 1.5 vertebrae. The number of anal rays is determined towards the end of the period when vertebral number is determined (ca. 160–300 D°, before hatching), but the number of rays in the dorsal and pectoral fins is established later (215–630 D°).

Shock treatment produced by specially great changes of temperature (ca. 10–14°C.), particularly during the sensitive period, may produce in the sea trout a difference of 3–4 vertebrae in offspring of the same parents. By cold and heat shock treatment applied to Danish sea trout, it has been possible to produce phenocopics of Scandinavian and Mediterranean forms of trout—so far as meristic characters are concerned.

Decreasing oxygen pressure leads to an increase in vertebral number in trout, whereas rising carbon dioxide pressure produces a decrease. Changes in acidity (pH) and in amounts of nitrates and phosphates have not been observed to produce any change in the number of vertebrae. Field observations concerning the affect of salinity on meristic characters have been rather inconclusive. However, Heuts' work on races of sticklebacks demonstrates that the selective influence of salinity produces a considerable difference in number of lateral plates.

Racial studies involving geographical variation of fishes is more difficult than previously thought because of the pronounced phenotypical dependence of some meristic characters on environmental factors.

VERTEBRATE SEXUAL CYCLES. By W. S. Bullough. Methuen's Monographs on Biological Subjects. Methuen & Co., Ltd., London; John Wiley and Sons, Inc., New York; 1951: viii + 117, 12 figs. $1.50.—Seasonal and oestrous reproductive cycles of the vertebrates are examined and an attempt is made to analyze those factors which are thought to determine, control or affect them. This is an interesting, up-to-date summary, with a glossary, a list of species discussed, a list of 203 references, and an index.

GENETICS AND THE ORIGIN OF SPECIES. 3rd ed. (revised). By Theodosius Dobzhansky. Columbia University Press, New York, 1951: x + 364, illus. $5.00.—The ten years since the appearance of the second edition of this work has, in Dobzhansky's words, "proved to be the most fruitful decade in the history of evolutionary thought since the appearance of Darwin's classic in 1859." There is now a common language spoken by geneticists, systematists, paleontologists, ecologists, embryologists and comparative anatomists interested in evolutionary problems. Only the fields of physiology and biochemistry still remain relatively little influenced by the evolutionary approach. This new edition is entirely rewritten; it is of wide scope, penetrating, and stimulating, and takes its place as a classic which should be at the elbow of all students of systematic biology. It is the best book in its field in the English language and will repay careful study by every biologist.

SOME REACTIONS OF PELAGIC FISH TO LIGHT AS RECORDED BY ECHO-SOUNDING. British Ministry Agr. and Fish., Fishery Inv., Ser. 2, 17 (1), 1952: 1–20, figs. 1–14. 4s.—Shoals of sprats and herrings show a diurnal migration which varies in different areas of the North Sea. This migration, up at night and down during the day, takes place in both feeding and non-feeding fish. Downward movement is associated with increase in light intensity, the fish remaining within a certain light intensity during the day. There appears to be a definite level at which the shoals remain during the night; specific gravity is a likely causal factor. Upward movement of the herring shoal, above that of the night level, immediately precedes the downward movement associated with increasing light at dawn. A similar upward movement is seen at dusk before the shoals settle to their night level.

Editorial Notes and News

Society owned set of Copeia THE Society-owned set of COPEIA which is in custody of the Editor-in-Chief is presumably complete to date. This set, for the years 1913 to 1951, inclusive, is now bound, complete with covers, in fifteen volumes, in green, water-proof Buckram, hand sewed, gold lettering, and each volume carries the name of the Society. Cost of binding was $46.90. The set includes the following numbers and indexes, bound in the following order: Nos. 1–13; Index to date (Dec. 31, 1914); Nos. 14–25; Index 1913, 1914, 1915 (Feb., 1916); Nos 26–51; Index 1913 to 1917 (Dec., 1917); Nos. 52–64 (No. 64 contains index for 1918); Nos. 65–76 (No. 76 contains index for 1919); Nos. 77–89 (No. 89 contains index for 1920); Nos. 90–101 (No. 101 contains index for 1921); Nos. 102–113 (No. 113 contains index for 1922); Nos. 114–125 (No. 125 contains index for 1923); Nos. 126–137; Index for 1924; Nos. 138–149; Index for 1925; Nos. 150–152; Supplement to No. 152 (March 25, 1926), Eric Knight Jordan; Nos. 153–161; Index for 1926; Nos. 162–165; Index for 1927; Nos. 166–169; Index for 1928; Nos. 170–173; Index for 1929; (from 1930 to date, COPEIA has appeared as four numbers per year) 1930–1936, each No. 4 contains index for the year; 1937–1938, each No. 4 contains index for the year and table of contents for the year (in binding, each table of contents was separated from No. 4 and inserted before No. 1 for the respective year); 1939–1951, each No. 4 contains index for the year, and accompanying each No. 4 is a separate table of contents for the year (these separate tables of contents are bound in front of the respective numbers). The Society-owned set is bound into volumes, as follows: Nos. 1–173 (1913–1929) in four volumes, and 1930–1951 (two years per volume) in eleven volumes.

Ichthyology at the Philadelphia Academy DR. ROBERT R. HARRY, who recently received his doctorate from Stanford University, has been appointed Assistant Curator of Fishes at the Academy of Natural Sciences of Philadelphia. A grant from the Catherwood Foundation, of Bryn Mawr, Pennsylvania, has enabled the Academy to expand and develop its Fish Department. Facilities for housing specimens have been considerably augmented by the installation of steel shelving and the transfer of materials to a much larger storage room.

HENRY W. FOWLER is continuing work on his compendium entitled *A Classification of Fish-like Vertebrates*, which he is illustrating. The illustrations include many drawings of the skeletons of fishes prepared in the 1800's by JOSEF HYRTL in Austria, and later purchased by E. D. COPE and left to the University of Pennsylvania. The text and drawings for the first volume are completed and much has been done toward the second volume, with material ahead for others. Fossil as well as Recent forms are included and the number of volumes is not yet predictable.

Exchange of Scientific Journals THE American Society of Ichthyologists and Herpetologists is frequently invited by institutions and other scientific societies to exchange COPEIA for another journal, usually exotic. Since the Society does not maintain a library, it has never been able to take advantage of these invitations. Yet the exchanges seem most desirable since they would result, generally, in an increased exchange of literature and, specifically, in a wider distribution of COPEIA. Since these results are so desirable and since the Society, itself, is unable to participate directly, the following procedure is suggested. Exchange offers received by the Society to date are listed below, and will be so listed in the future. Any member who would like to receive, personally, the journal offered should write to the Secretary. The member entering into the exchange will assume the responsibility of supplying COPEIA to the group or individual desiring the exchange. Such an exchange will be billed as a foreign membership, at $4.50, if the exchange journal is not domestic. This privilege is available to members only. (This is, essentially, a subsidy by the Society in order to disseminate COPEIA more widely.) After initial contact has been established through the Secretary, the member and the exchange journal will make their own continuing arrangements; the Secretary serves merely as a clearing house.

The following exchange offers are now in the Secretary's hands. Items which are already in possession of the Secretary are indicated by an asterisk (*).

1. * Bulletin of the Faculty of Fisheries, Hokkaido University. Vol. 2, Nos. 1–4, 307 pp., 1949–1952 (June to June basis). (Eight articles in English; 25 articles in Japanese with English summaries.)

2. Sarawak Museum Journal, Kuching. Prospectus is for papers on fishes and turtles off the shores of Sarawak and North Borneo.

3. * Journal of the Tokyo University of Fisheries,

Vol. 38, No. 1, 1951. 86 pp. (Seven articles in English; one in French.)

4. * The Science Reports of the Tohoku University, Vol. 19, No. 2, 1951, 53 pp., Sendai, Japan. Fourth Series, Biology. (Seven articles in English.)

5. * Memoirs of the College of Agriculture, Kyoto University, No. 59, 1951, Fisheries Series, No. 1, Kyoto, Japan. 81 pp. (Six articles in English.)

6. * The Journal of the Shimonoseki College of Fisheries, Vol. 1, No. 1, Japan, 1949. 118 pp. (One article in English; ten in Japanese with English summaries.)

7. * Bulletin of Hokkaido Regional Fisheries Research Laboratory, Fisheries Agency, Nos. 1–2, pp. 100, 1951, Japan. (Seven articles in Japanese with English Summaries.)

News notes

ON July 29, DR. WILLIAM BEEBE became Director Emeritus of the Department of Tropical Research, New York Zoological Society. His many, many friends in the ASIH wish him happiness and continued success in his retirement which undoubtedly will not be characterized by inactivity.

DR. HERNDON G. DOWLING, formerly of Haverford College, has joined the staff of the University of Arkansas as Assistant Professor of Biology.

DR. ARNOLD B. GROBMAN, Associate Professor of Biology, University of Florida, has been appointed Director of the Florida State Museum. In addition to his new duties he will continue his work with graduate students and will teach occasional courses at the University.

DR. JOHN KILBY has returned to his post as Assistant Professor of Biology, University of Florida, after a year and a half's service with the Air Force in Korea.

DR. JAMES A. PETERS has resigned his position with the Museum of Zoology, University of Michigan, and has accepted one with the Department of Zoology, Brown University.

DR. CARL L. HUBBS has received a Guggenheim fellowship for assistance in completing a long-time study of the freshwater fishes of Northeastern México. He plans to spend part of the summer and a sabbatical leave for the fall semester, 1952, at the University of Michigan.

The life history of the walleye in Michigan, Bull. Inst. Fish. Res. No. 3, 1950, 99 pp., by Paul Eschmeyer, has been reprinted and is available for $1.00 from the Institute for Fisheries Research, University Museums Annex, Ann Arbor, Michigan. Most of the initial stock of the bulletin was destroyed by fire in the Michigan State Office building.

DR. GEORGE K. REID, formerly of the University of Florida, is now Assistant Professor of Biology, College of William and Mary.

DR. L. C. STUART, Institute of Human Biology, University of Michigan, returned early in September after an 8-month continuance of his herpetological studies in Guatemala.

DR. ERICH WAGLER of Muenchen, outstanding authority on the biology and systematics of coregonids, died last year.

DR. WILHELM NÜMANN, formerly of the Institut für Seenforschung, Langenargen a. Bodensee, is now with the new Turkish Hydrobiological Institute. His address is Istanbul-Bebek, Insirah Sokak 38, Turkey.

JOHN T. NICHOLS, Curator of Fishes at the American Museum of Natural History, retired on June 30, 1952, but will continue his work at the Museum.

PAUL S. MARTIN, Museum of Zoology, University of Michigan, was awarded a National Science Foundation fellowship to continue work on his doctoral problem: an analysis of tropical animal habitats in northeastern México related to reptile and amphibian distribution patterns. MR. MARTIN will revisit southern Tamaulipas and adjacent San Luis Potosí, February through June, 1953.

Since 1939, when DR. SHIGEHO TANAKA retired, DR. TOKIHARU ABE has been in charge of the fish collections of the Zoological Institute of Tokyo University. He also works at Tokaiku Suisan Kenkyujo [East Sea Fisheries Reserve Laboratory], Tsukishima, Kyobashi, Tokyo, Japan. DR. ABE has been engaged in studies of the Tetraodontidae and other fishes of Japan.

Arrangements for a two-months expedition to the Galápagos Islands, 500 miles west of Ecuador, to collect data and fish specimens relative to the problems of poisonous fishes, shark attacks, and other noxious marine animals, have been made by Douglas Oil Company of California PRESIDENT WOODROW KRIEGER, sponsor, and DR. BRUCE HALSTEAD and associates at the Loma Linda (California) School of Tropical and Preventive Medicine. The expedition party of 14 was scheduled to leave Los Angeles November 25 aboard MR. KRIEGER's 96-foot yacht OBSERVER, which will serve as a floating base for the investigations and collections. Investigative activities are under the direction of DR. HALSTEAD, ichthyologist, who already has conducted similar investigations in the Marianas, Phoenix, Line and other island groups in the Pacific. The over-all investigations are being sponsored by research grants from the U. S. Public Health Service and Office of Naval Research. Scientists assisting DR. HALSTEAD are JEANNE BUNKER, NORMAN BUNKER, and LEONARD KUNINOBU, all of the Loma Linda School of Tropical and Preventive Medicine. Scientific pictures will be shot by DON OLLIS, nationally known professional photographer. The expedition to the Galápagos later will proceed along the coasts of

northern Chile, Perú, Ecuador, Panamá and other Central American areas.

The editors wish to thank MRS. HELEN T. GAIGE for assistance in the preparation of the index for 1952.

Financial aid Grateful acknowledgment is made to MR. THOMAS OELRICH for defraying the cost of the cut of the habitat plate illustrating his paper in this issue, and to Tulane University for financial aid in the publication of the CAGLE article.

Annual meeting, 1953 The 1953 annual meeting of the American Society of Ichthyologists and Herpetologists will be held in New York City, April 22 to 26. The Board of Governors will meet on April 22. DR. ROSS NIGRELLI is Local Chairman.

INDEX TO SCIENTIFIC NAMES

1952 Nos. 1–4

New names and their principal references are printed in bold face type

E

F

V

T

S

F

L

E

F
V

S

I

I
F
F

C

E
c

c

COPEIA IS THE JOURNAL OF THE AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS

Affiliations

The American Society of Ichthyologists and Herpetologists is a member of the American Institute of Biological Sciences and of the Division of Biology and Agriculture, National Research Council. An annual contribution is made to the publication of the Zoological Record.

Back numbers of COPEIA, as available, may be procured from Prof. N. B. Green, Biology Dept., Marshall College, Huntington, West Virginia. Prices will be furnished on application.

Subscription $6.00 per annum, $1.50 a copy.

Dues to the Society, $5.00 for members from the U.S.A., $4.50 for Canadian and foreign members, including subscription to COPEIA.

Life membership, $100.00, payable in one sum or four annual payments.

Dues and subscriptions are payable to the Society, through the Secretary.

Members should notify the Secretary immediately of any changes in address.

Manuscripts, news items, and all correspondence regarding the Journal should be addressed to one of the Editors.

Manuscripts should be submitted on good paper, as original typewritten copy, double-spaced, carefully corrected. Galley proof will be furnished authors.

Original contributions, not to be published elsewhere, are alone acceptable.

Reprints are furnished at approximate cost.

Figures, author's corrections, expensive tabular matter and unusually long articles may be charged in whole or in part to the author at the discretion of the Editors.

ΙΧΘΥΣ
ΒΑΤΡΑΧΟΣ
ΕΡΠΕΤΟΝ

C 37